FINAL PREVIEW OF NATIONAL MEETING—p. 18-A–27-A

Forest Products Journal

Ralph H. Bescher Becomes FPRS Tenth President, Succeeding Moss B. Christian, June 5—p. 28–A

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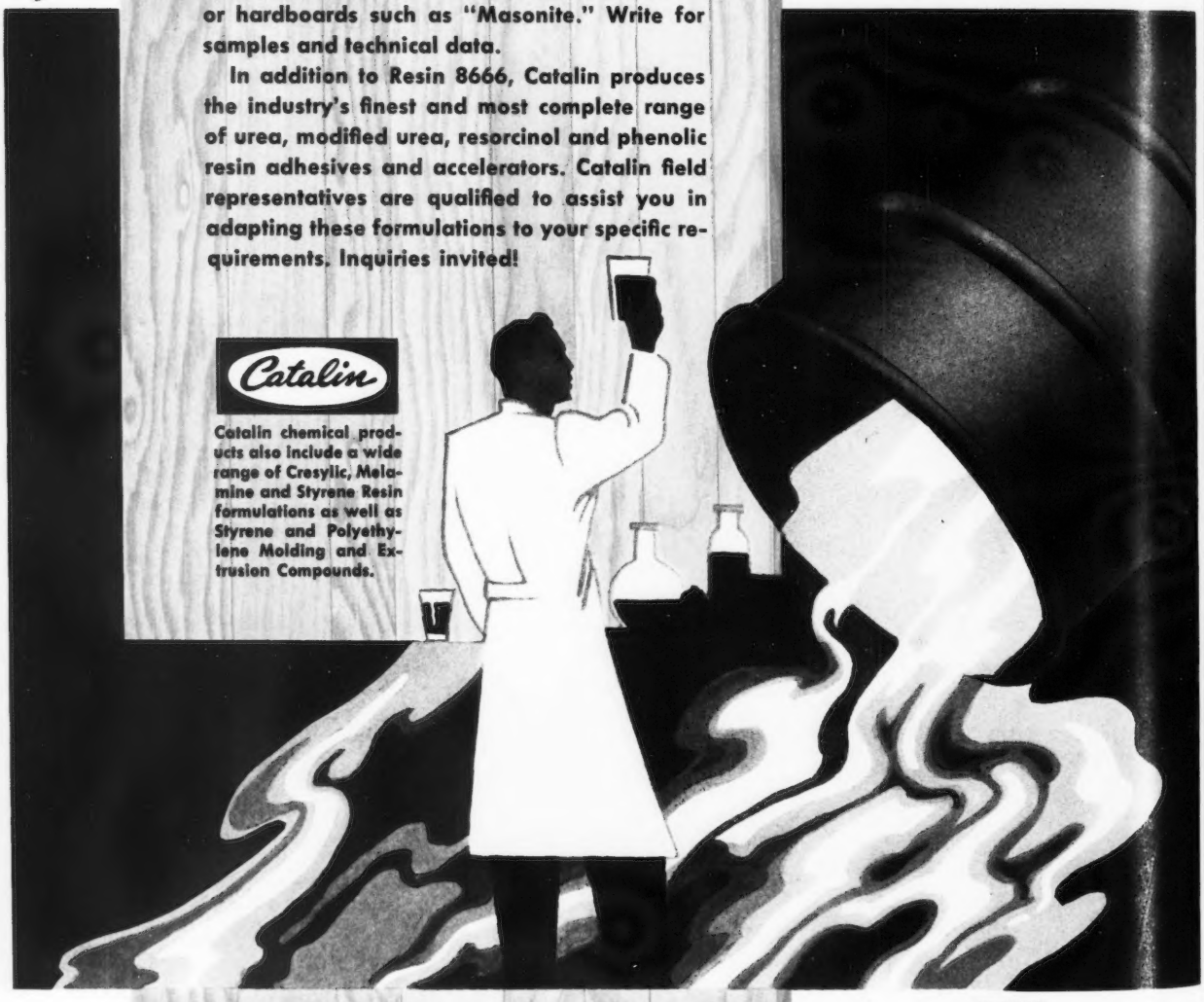

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FOREST PRODUCTS JOURNAL

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IMPORTANT FPRS DATES

June 4–7: Tenth National Meeting, Asheville, N. C.

Sept. 1956: Joint Meeting of Inland Empire and Pacific Northwest Sections, Lewiston, Idaho

Oct. 1956: Midwest Section Meeting, Rockford, Ill.

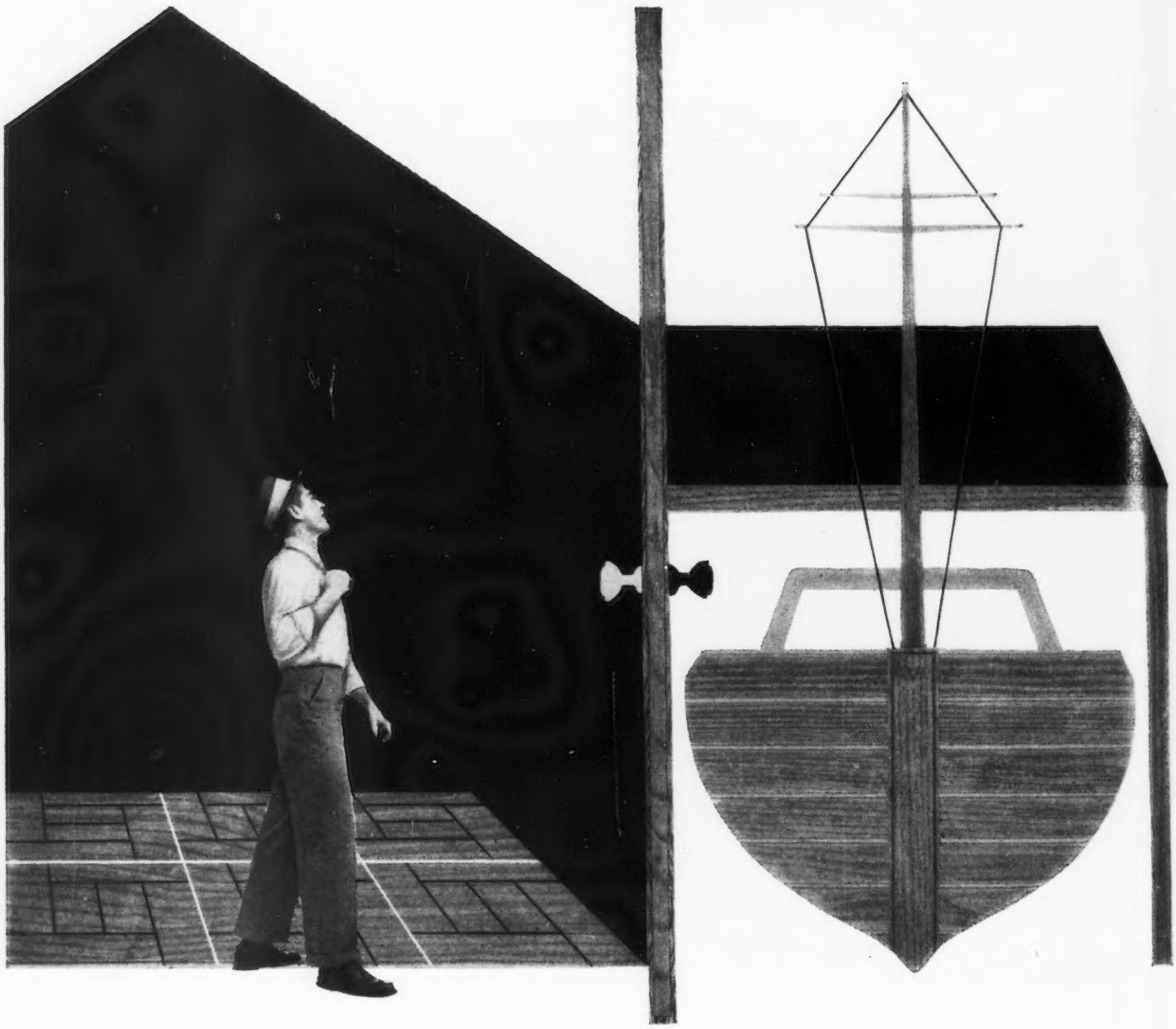
Oct. 1956: Upper Mississippi Valley Section Meeting, Wausau, Wisconsin

Fall 1956: Carolinas–Chesapeake Section Annual Meeting, Pinehurst, N. C.

Fall 1956: Mid-South Section Annual Meeting, Laurel, Miss.

Dec. 7–8: Florida–Georgia–Alabama Section Annual Meeting, Athens, Ga.

June 24–28, 1957: Eleventh National Meeting, Buffalo, N. Y.



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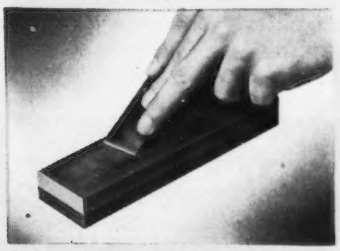

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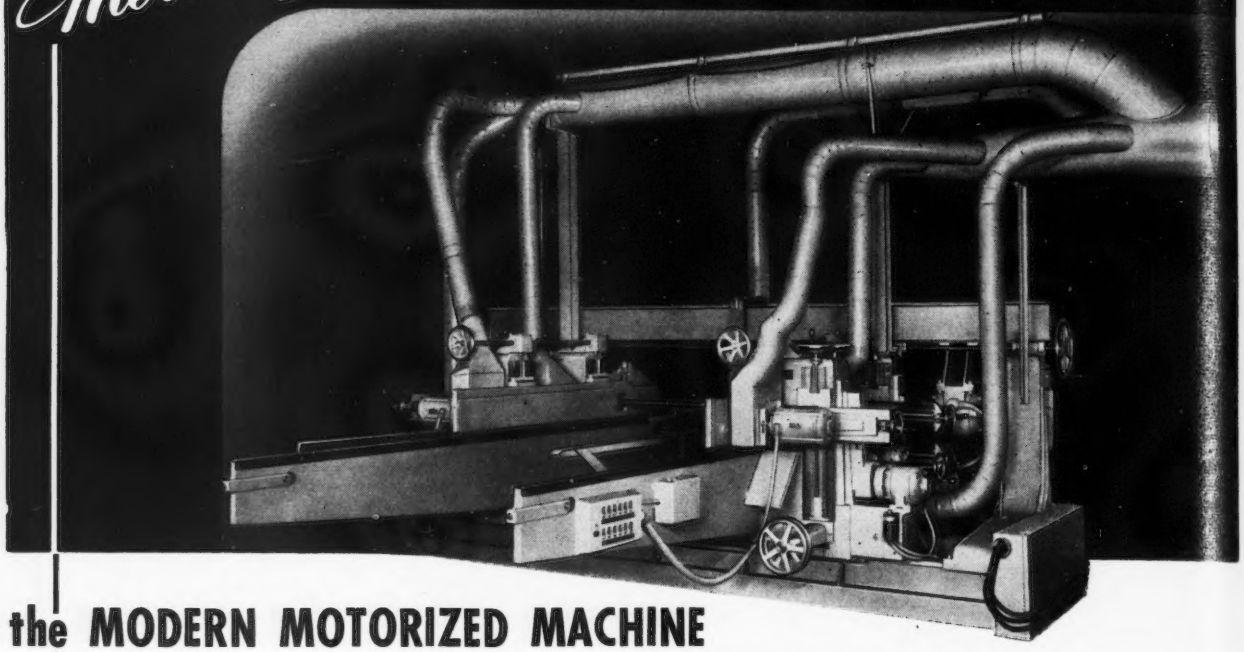

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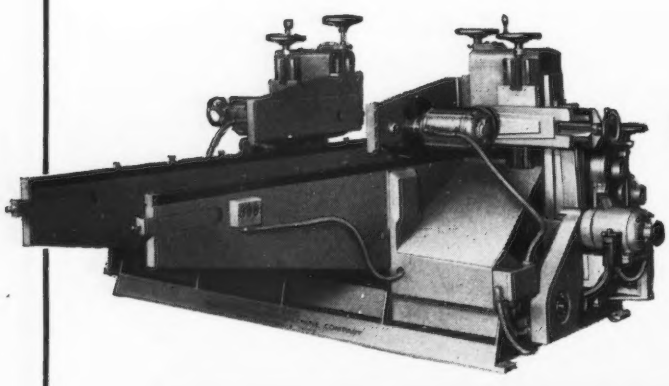

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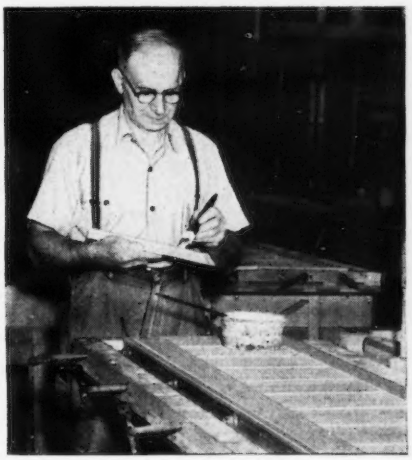

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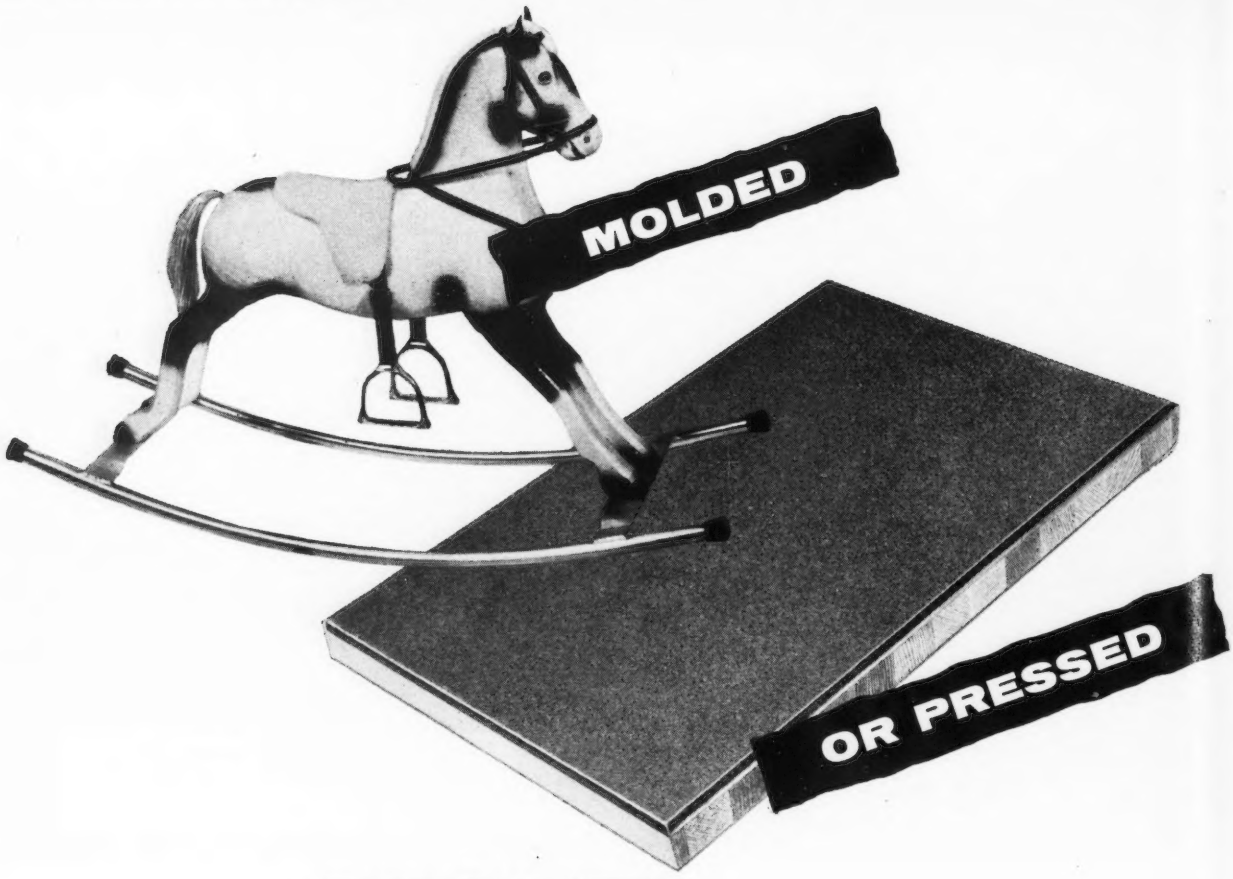

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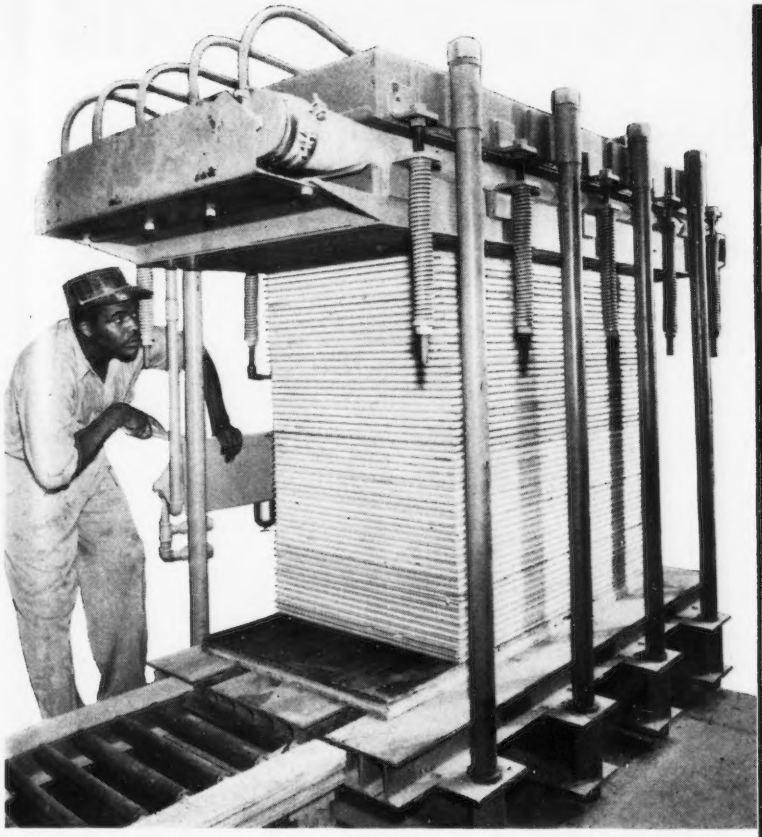

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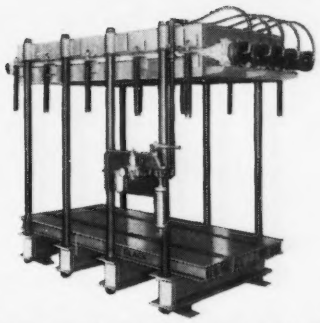

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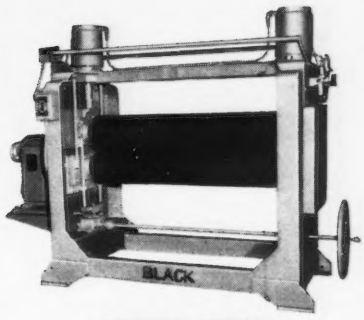

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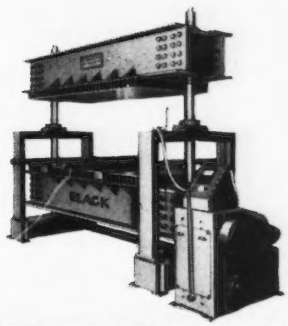

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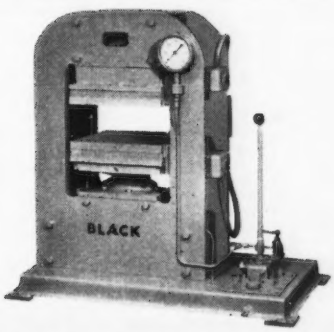

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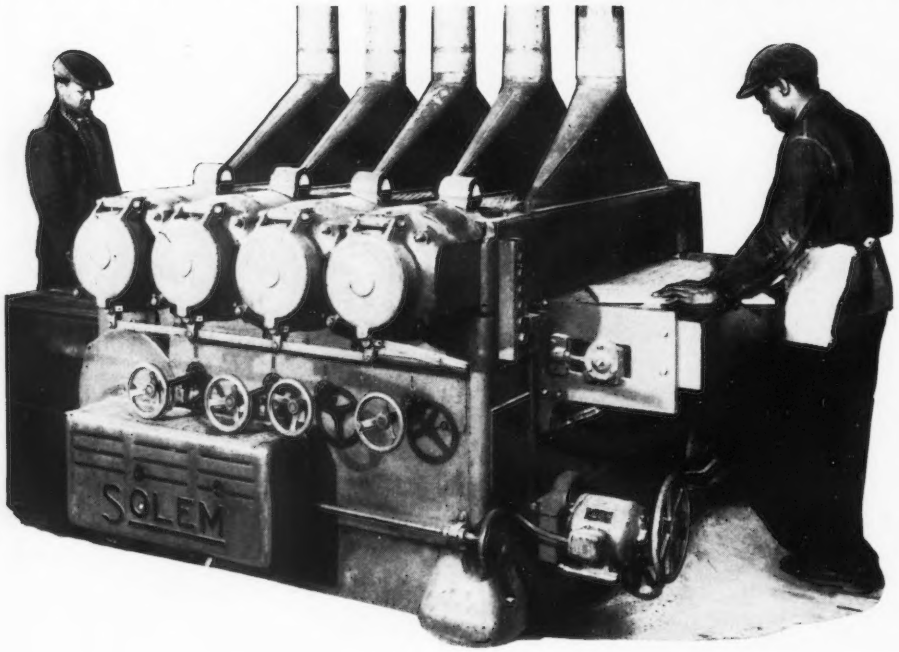

A Solem Endless-Bed 4-Drum Sander in operation at the Anderson–Tully Co., Memphis, Tennessee.

You see them in action everywhere—that is everywhere in furniture, cabinet works and plywood factories, where a fine finish is not only desirable, but essential. The SOLEM ENDLESS-BED DRUM SANDER really turns out the work and plenty of it, because the production capacity is built into the machine.

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SOLEM DRUM SANDERS are made in endless-bed and double-deck models in a variety of widths and numbers of drums. There's a type and size to fit your needs.

Merritt–Solem Division of Solem Machine Company manufactures other machines needed in manufacture of plywood and veneer, a few of which are shown to the right. Solem Quality Is Built Into Them, Too.

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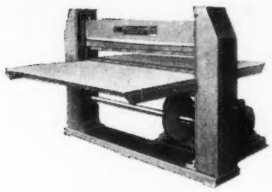

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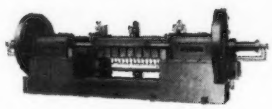

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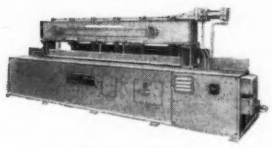

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Crawford Furniture Company

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"Jake" Johnson has been with Crawford since 1944. He points with pride to a family comprising two sons (both furniture industry executives) three daughters—and eight grandchildren.

He is an amateur horticulturist—and loves boating and fishing—when time permits him to indulge.

ARTHUR PAIS
Laminite Plastics Corporation

LAMINITE PLASTICS is one of the pioneers in large-quantity, top-quality plastic table top manufacturing . . . and Art Pais has been in on Laminite's development from the start. In fact, his associates tell us that he has had a hand in every operation from ordering raw materials to selling his company's finished product. Being the kind of genius who can improvise a machine with a wrench and a handful of bolts, Art Pais is largely responsible for developing many new automatic processes which are now used throughout the plastic top industry.

Friendly as a hound-dog pup at mealtime, Art Pais is well spoken of by everybody—including his competitors.

Married, and the father of two boys and a girl, Mr. Pais reports Hi-Fi as his hobby . . . and home the place not to run away from—except to the business of laminating table tops which Laminite does a lot of, with the aid of National Casein glues.

Do you realize just how many really vital glue jobs there are—from laminating intricate panels for fine musical instruments to giant trusses to support a roof? Is it any wonder that we of National Casein take so seriously this job of delivering the right glue for your job—where you want it, when you want it, and how you want it—tank car, tank truck, drum or bag!

Purpose of our series on "Men Who Know Glues" is to stimulate our own and your thinking on the subject of glues as well as to remind you that you'll stick with National Casein glues—because they stick for you.

National Casein

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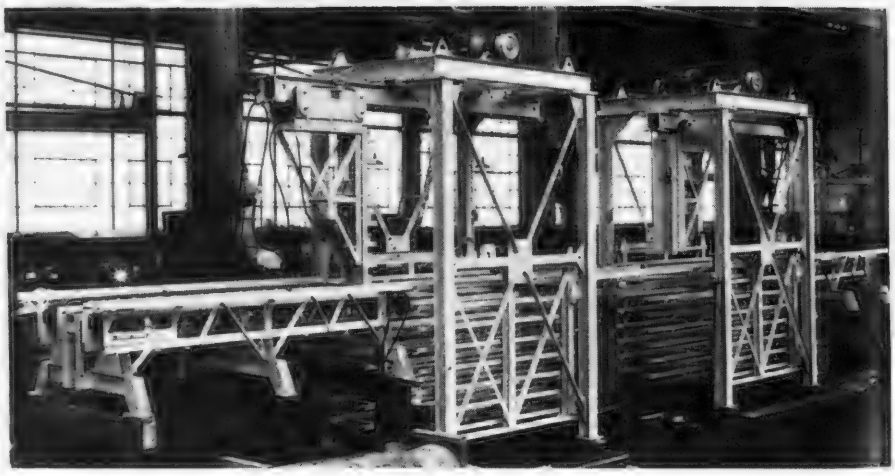
New particle board plant to use Washington "package" press installation



Above is the particle board press for Poinsett Lumber & Manufacturing Company, shown as it underwent final testing in the Washington plant prior to delivery. At right is the injector, loader, unloader and ejector designed for use with the press.

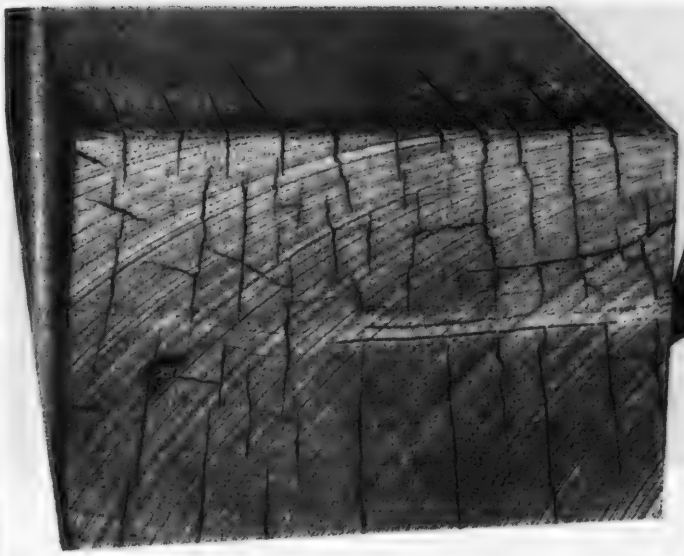
PRODUCTION of particle board will begin in the early summer of 1956 in the new plant of Poinsett Lumber & Manufacturing Company, at Pickens, South Carolina, a subsidiary of Singer Manufacturing Company. Key unit in the finishing stage of particle board manufacture will be an automatic hot plate press designed and manufactured by Washington Iron Works for Miller–Hofft Inc., who designed and installed this complete plant. This 8-opening Washington press has a platen area of 58" by 102" and an operating pressure of 500 psi.

In addition to the press, Washington Iron Works designed and built the loader, unloader, injector and ejector. These units comprise a completely automatic finishing stage operation . . . a complete "package".

Many plywood, hardboard and particle board plants are finding this Washington equipment "package" the answer in finishing stage operation. Washington presses and accessory loading and unloading units are integrally engineered to fit the job and assure reliable and economical performance typical of Washington Iron Works designed and built equipment.

WASHINGTON IRON WORKS

1500 Sixth Avenue South Seattle 4, Wash. **Eliott 1292**



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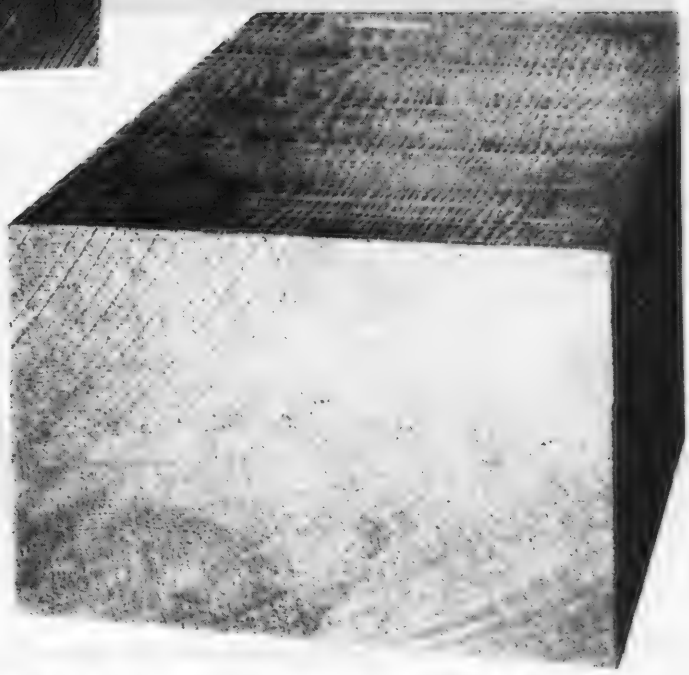
SEALTITE prevents them!



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Five months to build and equip—
Five days to tune up for 24 hour production—
Five lineal feet every two minutes—20 square feet.

Resin bonded particle board is produced by a Chipcraft vertical Extruder in dimensions up to 12′ x 4′ x 1¾″ thick with a minimum change-over. Chipcore board made at the Hart plant meets every test of workable, serviceable, economical core board for most wood working purposes and wood products.

Chipcraft Extruders are designed and engineered for sound dependable wood waste utilization, high level quality and low cost operation with densities from .3 with fluted boards up to that of solid wood.

A Chipcraft Extruder is recommended by users because:

—it is fully automatic with minimum operating labor cost.
—it is flexible, easily adjustable for all board sizes.
—it is versatile; makes solid board or fluted board out of any wood waste.
—it is economical in operation.
—it is adaptable to existing space and building limitations, inside or out; can be vertical or horizontal in installation.
—it is available for installation and operation within months; while standard in design and operation, each project is custom engineered and fitted to the purpose and place desired.

Ask for information and advice without cost, on automatic wood waste utilization—extruding and moulding systems.

CHIPCRAFT COMPANY, INC.

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A-M SERVICE

FOR BETTER WOOD PRODUCTS

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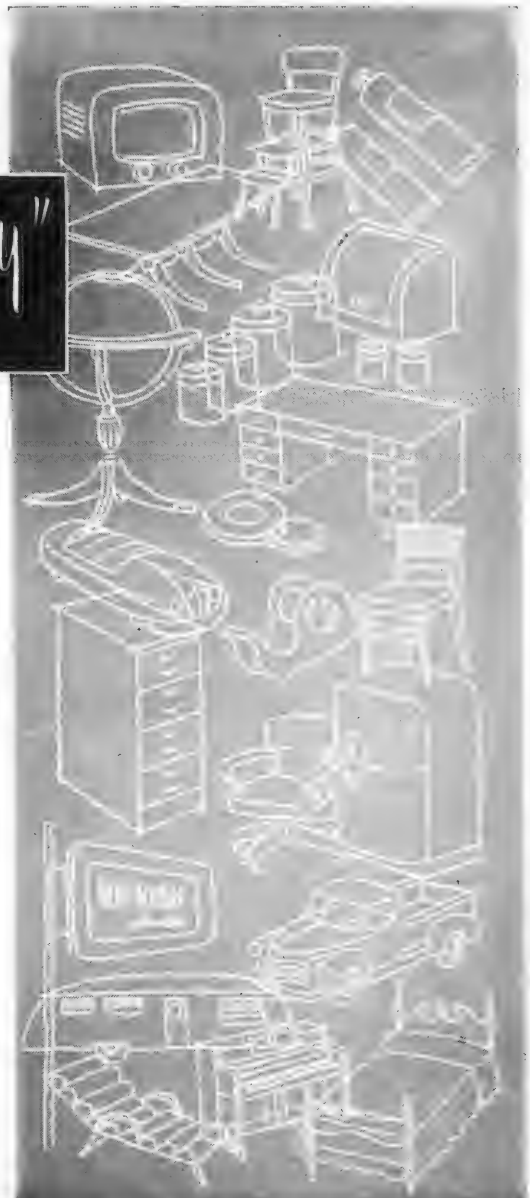
"Coatings by Lilly"



Whatever the product—whether it be **METAL...WOOD...PLASTIC or PAPER**—there's a Lilly coating made to fill the finishing requirements of manufacturers' individual needs. Development of coatings for specific use is an important part of the technical services designed by Lilly to help industry in the field of finishing. Contact your nearest Lilly plant.

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METAL LITHO COATINGS • STAIN and WOOD FILLERS

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Another Synvar first . . .

New hardeners mean superior bonds with Synvar urea glues

Synvar urea resin with new Hardener 190 series is the answer to hot press bonding and laminating, lumber core gluing, chip core manufacture, high frequency assembly and edge gluing.

The Lane Company, manufacturers of famous top quality Lane cedar chests, uses Synvar urea resins for superior woodworking bonds. Again proving that Synvar serves the Leaders of American Industry.

Here's why!

Synvar hardeners are custom-made for elevated temperature cures. Hardener 190 series gives overnight pot life, *or longer!* Increased proportion of the hardener speeds up cure at temperatures above 230° F., at press temperatures. Best of all, pot life does not depend upon the age of hardeners . . . working properties remain the same regardless of temperature and weather conditions!

Eliminate pre-cure, safe to handle

Synvar hardeners eliminate the danger of pre-cure in long assembly operations. They do not lose strength when left in open container . . . emanate no obnoxious odors . . . are easier and safer to handle. Synvar hardeners start to cure the resin at temperatures close to the press cure temperature.

At lower temperatures they cure very slowly, allowing the use of hot cores or veneers without danger of pre-curing and without the necessity of cooling.

Excellent for chipcore operation

Synvar hardeners are especially suited to the manufacture of chipcore. As pre-curing is eliminated, more resin is actually available for bonding the chips, resulting in stronger and better board. Because the hardeners are stable, glues are not affected by seasonal temperature variations.

Save time, save money on all woodworking operations. Send for literature on Synvar's complete line of woodworking resins.

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SYNVAR CORPORATION

WILMINGTON 99, DELAWARE

Experienced service to customers is our greatest achievement . . . customer progress and satisfaction our greatest reward.

HOT & COLD
Production PRESSES

If your company is expanding or if you are "new comers" in the plywood, veneer or hardboard field, consider WILLIAMS-WHITE & CO. custom built hot or cold presses before you buy! Built to your exact requirements, WILLIAMS-WHITE presses represent the peak of up-to-date design and craftsmanship.

Your specifications as to capacity, plate size, number of openings, types of controls, etc., are built into each WILLIAMS-WHITE hot or cold press. They are available in column or A-frame construction, with steam, fluid or electrically heated plates.

Above is a typical WILLIAMS-WHITE laboratory press, of 90 tons capacity, plate size 38" x 24" and daylight opening 12 inches.

At right is a WILLIAMS-WHITE cold press of 575 tons capacity, with plate size 106" x 54" and adjustable daylight opening, 80 to 123 inches.

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FPRS NEWS-DIGEST

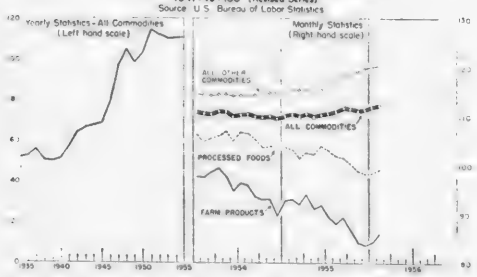
Volume VI | MAY, 1956 | Number 5

GRAPHIC TRENDS

WHOLESALE PRICE INDEXES

1947-49=100 (Revised Series)

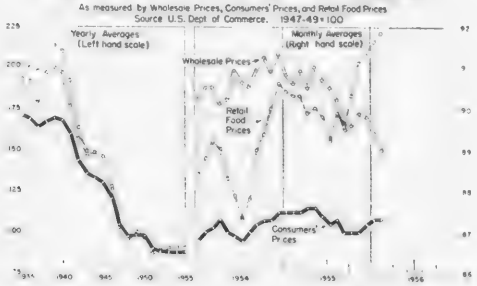
Source U.S. Bureau of Labor Statistics



PURCHASING POWER OF THE DOLLAR

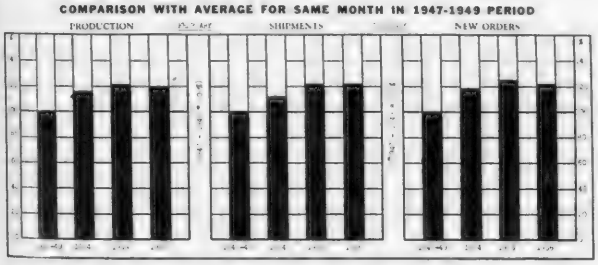
As measured by Wholesale Prices, Consumers' Prices, and Retail Food Prices

Source U.S. Dept of Commerce. 1947-49=100



Lumber and Hardwood Flooring

COMPARISON WITH AVERAGE FOR SAME MONTH IN 1947-1949 PERIOD



RESOURCES—PLANNING MOST EFFECTIVE USE of nation's natural resources by wider employment of conservation specialists was urged at conference of industry, university, and government representatives at U. of Michigan last month. In next two decades, the U. S. with less than one-tenth of earth's population and land area, will continue to use half of world's resources and materials, according to Conservation Foundation.

BUSINESS OUTLOOK

FURNITURE—RECORD FIRST QUARTER of '56 shipments was reported by furniture industry, with shipments up 26% over same period last year. Employment and payrolls during first three months remained constant, with payrolls 16% ahead of '55 and employment up 7%.

—NAFM

RESEARCH—DRYING SAWMILL RESIDUES by introducing particles into a hot gas stream 500 to 1500° F. has been suggested by Oregon Forest Products lab researchers. "Suspension drying" may be economical method of drying raw material for chipcore, briquets, and molded products. The process, which achieves drying in seconds, has already been used to dry bark, coal, starch, lignite.

—Industrial Research Newsletter

BUILDING CODES—MILLIONS OF DOLLARS could be saved by home owners through modernization of building codes, says Richard G. Kimbell, NLMA vice-president. Restrictions vary in different cities. Example of benefits to home buyers when city brings code up to date: "Home construction savings in Denver in 1955 amounted to more than $3.5 million after liberalization of its building code."

FREIGHT RATES—RECENT HIKE in rail freight rates may affect all wood products users. Lumber was exempted from full boost which became effective March 15, but increase in some cases could be substantial 6%. Higher shipping costs may be passed on to customers, affecting both furniture and building material prices.

—Veneer Newsletter

ADVANCE REGISTRATION INDICATES RECORD ATTENDANCE AT FPRS NATIONAL MEETING

ASHEVILLE, N. C.—This beautiful city in the "Land of the Sky" will be the scene of FPRS Tenth National Meeting June 4–7. Located deep in the Southern Appalachian Mountains at an elevation of 2,300 feet, Asheville combines the many advantages of a modern city with the facilities for a delightful mountain vacation. It is often called the "Convention City of the Carolinas."

Advance registration indicates a record turnout of more than 1,000 persons will attend the meeting and the FPRS Suppliers Exhibit. Fourteen technical sessions with more than 60 papers have been scheduled on every phase of forest products research, development, production, utilization, and marketing. In conjunction with the meeting, more than 70 firms and educational institutions will participate in the 95-booth FPRS Suppliers Exhibit.

Registration

Registration desks will be in the lobby of the City Auditorium, Convention Headquarters. The desks will be staffed Sunday, June 3, from 2:30 to 6:00 p.m; Monday and Tuesday, June 4 and 5, 8:30 a.m. to 5:30 p.m.; Wednesday, June 6, 8:30 a.m. to 12 noon; and Thursday, June 7, 8:30 a.m. to 5 p.m.

The registration fee is $7.50 for FPRS members, $10 for non-members, and includes admission to all technical sessions, committee meetings, plant tours, and the Paul Bunyan Barbecue. Ladies registration fee is $4.00.

President Moss B. Christian will officially open the meeting at 9 a.m. Monday, June 4, when he welcomes registrants to Session I, Quality Control in Wood Products, in the City Auditorium. Other sessions will be conducted throughout the week in the Auditorium and the George Vanderbilt and Battery Park Hotels.

The meeting will be culminated on Friday, June 8, when ten leading forest products companies in the Carolinas open their doors to FPRS registrants. Transportation will be provided on tours to the following plants: Broyhill Furniture Factories, Lenoir, N. C.; Drexel Furniture Co., Drexel, N. C.; Morgan Manufacturing Co., Black Mountain, N. C.; Champion Paper and Fibre Co., Canton, N. C.; Ecusta Paper Corp., Pisgah Forest, N. C.; Williams-Brownell, Inc., Asheville; Draper Corp., Swannanoa, N. C.; Taylor-Colquitt Co., Spartanburg, S.C.; Poinsett Lumber and Manufacturing Co., Pickens, S. C.; American Enka Corp., Enka, N. C.

HOST COMMITTEE for 10th National Meeting includes, front row: J. S. Bethel, Exhibits; Mrs. W. R. Smith, Ladies Program; G. M. Hill, Finances; W. L. Irwin, Entertainment; back row: E. S. Harrar, General Chairman; H. J. Loughead, Publicity; J. B. Hayward, Paul Bunyan Barbecue; Walton R. Smith, Asheville Arrangements.

Official Luncheon

Retiring President Moss B. Christian and new President Ralph H. Bescher will be honored at the FPRS Official Luncheon on Tuesday, June 5. Principal speaker will be Reuben B. Robertson, Sr., president and chairman of the board of Champion Paper and Fibre Co., Canton, N. C.

Certificates and cash awards for outstanding graduate student research in forest products will go to the top two papers entered in the 7th annual "Wood and Wood Products Award" competition sponsored by Vance Publishing Co., Chicago. First place winner will receive $350 and second place $150.

The official luncheon will follow the Annual Business Meeting at 11 a.m., Tuesday, June 5 when the gavel of the presidency will be turned over to Mr. Bescher by Mr. Christian. New officers will be introduced, committee and business reports given, and other Society business conducted.

PLANT TOURS on Friday, June 8, will include Carolinas Division mill of Champion Paper and Fiber Co., Canton, N. C. Total of ten plants will be visited.

Program Features

Open meetings of the Society's 13 subject matter committees will be conducted throughout the week. The FPRS Suppliers Exhibit will be open daily, with representative displays of raw materials and equipment used in the production of wood products. (See page 26-A.)

Employment Service

There will be an informally conducted employment service throughout the meeting, with Chairman Newell Norton and members of his committee available for interviews. This service is both for employers who are seeking personnel and men who are looking for positions.

Ladies Program

A trip through the famous Biltmore Estate will be a feature attraction for the ladies. Their program will also include a get-acquainted-hour and a tea, with Mrs. Christian and Mrs. Bescher as hostesses. Children's parties are being arranged at the same times as the ladies' events.

Official Technical Program

Forest Products Research Society Tenth National Meeting

June 4–7, 1956 Asheville, N. C.

ession I—Quality Control in Wood Products

9:00 **a.m. Monday, June 4: City** .uditorium. Chairman: C. S. Lati-er, Nickey Brothers, Memphis, Tenn. Presiding Chairman: Ben S. .yant, U. of Washington, Seattle

Management Possibilities with Quality Control Methods"—C. A. Bicking, Office of Chief of Ordnance

"Some Experimental Designs Applicable to Problems with Wood"—R. J. Hader, N. C. State College

"An Application of Linear Programming to the Plywood Industry"—J. S. Bethel, N. C. State College

"Acceptance Sampling of Veneer Using the Lot-Plot Plan"—A. E. Wylie, State U. of New York College of Forestry, and W. C. Hitchings, White Manufacturing Co.

"Statistical Sampling Proves to be Efficient and Accurate in Receiving Inspection"—L. O. Reed and R. T. White, Brunswick–Balke–Collender Co.

Session II—A Practical Approach to the Prevention of Decay and Termites in Building Construction

9:00 **a.m. Monday, June 4: Gold Room, Battery Park Hotel.** Chairman, Ira Hatfield, Wood Treating Chemicals Co., St. Louis, Mo. Presiding Chairman: R. M. Lindgren, U. S. Forest Products Laboratory, Madison, Wis.

Panel Discussion:

"Can Wood Be Used Successfully and Economically in Home Building Today and Will It Perform as Well as Competitive Products?"—Representative, NLMA

Building Contractor—W. L. G. McKenzie, Fiske–Carter Construction Co.

Commercial Termite Control Operator—M. W. Smith, Hill–Smith Termite Control Co.

Supplier of Treated Wood—M. P. Brown, Taylor–Colquitt Co.

Architect

Session III—Preservation of Wood Materials Used in Building

2:00 **p.m. Monday, June 4: Gold** .oom, Battery Park Hotel. Chair-.n: Ira Hatfield. Presiding Chair-.n: C. S. Walters, U. of Illinois, Champaign, Ill.

.low and What to Specify for the Pr .rvative Treatment of Wood to be Used in Buildings"—R. B. Putman, Koppers Co.

"Use of Preservatives in Board Products"—W. L. Meek, Minnesota and Ontario Paper Co.

"How to Prevent Fungus Damage to Wood Structures"—A. F. Verrall, Southern Forest Experiment Station

"The Oscillating Pressure Method of Wood Impregnation"—M. S. Hudson, Consulting Chemist, and S. T. Henriksson, Boliden Mining Co., Sweden

"How to Prevent Insect Damage to Wood Structures"—R. J. Kowal, Southern Forest Experiment Station

"A New Method for Long Term Preservation of Wood by Chemical Modification"—E. Abrams, Southern Research Institute; F.G.W. Smith and S. Miller, University of Miami Marine Laboratory; R. R. Bottoms, National Cylinder Gas Co.

"A New Method for Applying Pentachlorophenol to Wood in Place"—R. G. Van Allen, Wood-Treating Chemicals Co.

Session IV—Marketing—A Management Tool from Production Through Retailer

2:00 **p.m. Monday, June 4: City Auditorium.** Chairman: P. H. W. Creden, Edward Hines Lumber Co., Chicago. Presiding Chairman: Mr. Creden

"Activities of NLMA Trade Promotion Committee Relating to Markets"—L. J. Carr, L. J. Carr & Co.

"Building the Treated Wood Market in the 3-I Area"—D. C. Neuchterlein and J. H. Secor, Jr., Dow Chemical Co.

"New Perspectives for a Growing Giant"—P. H. W. Creden

Session V—Keeping Abreast in Wood Gluing

2:00 **p.m. Monday, June 4: East Ballroom, George Vanderbilt Hotel.** Chairman: Alan A. Marra, U. of Michigan, Ann Arbor. Presiding Chairman: Thomas R. Truax, U. S. Forest Products Lab, Madison. Program Chairman: D. B. Richards, Alabama Polytechnic Institute, Auburn

"Recent Developments in Fast-Setting Adhesives"—George W. Koehn, Armstrong Cork Co., Keynote Speaker

"High Pressure Decorative Laminates"—Joseph Coufal, National Adhesives

"Performance of Urea-Resin Glues at Elevated Temperatures"—R. F. Blomquist and W. Z. Olson, U. S. Forest Products Laboratory

"Some Factors Affecting the Performance of Wood Adhesives in Thick Glue Lines"—The late Edward Hinken. Read by S. B. Preston, U. of Michigan

Session VI—Keeping Abreast in Wood Gluing

2:00 **p.m. Tuesday, June 5: East Ballroom, George Vanderbilt Hotel.** Chairman: Alan A. Marra. Presiding Chairman: J. S. Bethel, N. C. State College, Raleigh, N. C. Program Chairman: D. B. Richards

"Production and Quality Control of Laminated Timbers"—M. J. Rhude, Unit Structures, Inc.

"Production Gluing of Random Length Stock"—H. B. Reed, Raybond Electronics

"Safe Bending Radii for Curved Laminates"—W. J. Finnorn, Timber Engineering Co., and Andrew Rapavi, Bureau of Ships

"How Long Will It Last—A Study of Glue Line Durability"—J. W. Maxwell and C. C. Booth, The Borden Co.

Session VII—Improved Techniques for Wood Drying

2:00 **p.m. Tuesday, June 5: Gold Room, Battery Park Hotel.** Chairman: L. D. Espenas, Oregon Forest Products Laboratory, Corvallis. Presiding Chairman: W. R. Smith, Southeastern Forest Experiment Station, Asheville

"Concept of Moisture Movement in Veneer Broadened by Diffusion Calculations"—W. K. Loughborough, Consultant

"Estimating Moisture Content of Lumber During the Drying Process"—W. E. Pratt, California Redwood Association

"Comparison of Three Methods of Determining Whether Southern Pine Poles Are Well Air Seasoned"—J. S. Mathewson, U. S. Forest Products Laboratory and P. J. Berger, Cincinnati Gas and Electric Co. (By title only)

"Uncover Losses and Cover Seasoning Yards"—R. M. Carter, N. C. State College

(Continued on page 20–A)

Session VIII—Chemicals from Lignin, Hemicellulose, and Other By-Products

2:00 p.m. Tuesday, June 5: Pisgah Room, Battery Park Hotel. Chairman: R. C. Sproull, Philip Morris Co., Richmond, Va. Presiding Chairman: E. G. Locke, U. S. Forest Products Laboratory

"Whole Tree Harvesting—Pulp and Paper from Different Sections of Pine Trees"—R. C. Sproull, W. L. Belvin and R. B. Parker, Herty Foundation

"Effect of Swelling Agents and Catalysts on Esterification of Wood"—F. Bender and L. P. Clermont, Forest Products Laboratories of Canada

"The Separation and Utilization of Hemicellulose"—J. F. Harris, J. F. Saeman, and E. G. Locke, U. S. Forest Products Laboratory

"Nature of Aspen Lignin"—I. A. Pearl, Institute of Paper Chemistry

"Quercetin from Douglas-Fir Bark"—A. S. Gregory, D. L. Brink, L. E. Dowd, and A. S. Ryan, Weyerhaeuser Timber Co.

"Alkali and Thio Lignins from Pine Bark"—J. B. Doughty, F. W. Taylor, and W. T. Henerey, West Virginia Pulp and Paper Co.

Session IX—Wood Machining

9:00 a.m. Wednesday, June 6: City Auditorium. Chairman: L. A. Patronsky, Wabash Screen Door Co., Minneapolis, Minn. Presiding Chairman: R. V. Reynolds, Kennametal, Inc., Latrobe, Pa.

"Sanding Particle Board to Thickness"—David A. Haile, Rock Island Millwork Co.

"The Effect of Boring Speed and Feed Rate on the Strength of Glued Dowel Joints in Tension"—R. J. Hoyle, Jr., State U. of New York College of Forestry

"Analysis of Lumber Planing Process, Part II"—Peter Koch, Michigan State University

"Greater Utilization of Material Obtained from New Machine"—W. K. Murphey, Ohio Agricultural Experiment Station, and G. L. Schneider, Lexington, Ohio

"Industrial Noise Problems in the Woodworking Field"—N. S. Symons, Legal Consultant on Industrial Noise to Associated Industries of New York State

Session X—More Complete Utilization in Logging and Milling

9:00 a.m. Wednesday, June 6: East Ballroom, George Vanderbilt Hotel. Chairman: F. C. Simmons, Northeastern Forest Experiment Station, Upper Darby, Pa. Presiding Chairman: E. L. Demmon, Southeastern Forest Experiment Station, Asheville, N. C.

"Chip Yield and Materials Balance as Related to Log Size in the California Pine and Fir Region"—N. T. Shelton, Diamond Match Co.

"Wastewood Chippers"—J. J. Copeland, Masonite Corp.

"Reducing Sawmill Waste 90% in Six Years"—E. P. Ivory, Ivory Pine Co.

"The Future of Rubber-Tired Tractors in Logging"—W. E. McCraw, Caterpillar Tractor Co. Discussion by H. T. Larmore, Allis–Chalmers Manufacturing Co.

"Logging Injury in Central States Upland Hardwoods"—D. E. Herrick and G. H. Deitschman, Central States Forest Experiment Station. Discussion by K. Trowbridge, North Carolina Pulp Co.

"Genetic, Growth and Environmental Factors Affecting Specific Gravity of Loblolly Pine"—B. Zobel, Texas Forest Service. Discussion by E. Schreiner, Northeastern Forest Experiment Station

"Development of an Automatic Sawmill Carriage Feed"—M. H. Mater, Mater Engineering (By title only)

Session XI—Composition Boards—What the User Wants

9:00 a.m. Thursday, June 7: City Auditorium. Chairman: George G. Marra, Washington State Institute of Technology. Presiding Chairman: G. M. Hill, Drexel Furniture Co.

"Properties of Composition Board in Relation to Their Use in Furniture Manufacture"—E. S. Johnson, A. Carlyle, L. McGee and R. McLean, N. C. State College

"The Use of Composition Boards and Other Wood Base Materials in Mass Home Building"—W. J. Worth, National Homes Corp.

"Composition Board Has Found Its Place in the Furniture Industry"—R. H. Yale, Poinsett Lumber and Manufacturing Co.

"Insulating Fiberboard Roof Deck"—Paul D. Close, Simpson Logging Co.

Session XII—How to Select a Better Finish for Furniture

9:00 a. m. Thursday, June 7: East Ballroom, George Vanderbilt Hotel. Chairman: E. S. Johnson, N. C. State College. Presiding Chairman: J. T. Geoghegan, E. I. du Pont de Nemours Co., Atlanta, Ga.

"New Approaches in Wood Finishing"—A. J. Kirsch, American Cyanamid Corp.

"Discoloration of Furniture Finishes"—Donald Lubeck, Hammond Organ Co.

"Evaluating Cold Check Resistance of Furniture Finishes"—Roy Carter and W. J. Schrumpf, N. C. State College

"Synthetics vs. Nitro-Cellulose Lacquers"—W. M. Beaver, Marietta Paint and Color Co.

Infra Red Drying of Wood Finishes"—I. J. Barber and P. H. Kropp, Fostoria Pressed Steel Co.

Film—"Modern Wood Sanding"—Behr-Manning Co.

Panel Discussion—Including presentation of "Beautyguard" finish developments

Session XIII—Packaging and Shipment of Furniture

2:00 p.m. Thursday, June 7: Gold Room, Battery Park Hotel. Chairman: K. W. Kruger, U. S. Forest Products Laboratory. Presiding Chairman: R. F. Weber, Packaging Consultant, Milwaukee, Wis.

"Furniture Manufacturers' Viewpoint on Protection of Furniture for Shipment"—S. W. Freeman, Drexel Furniture Co.

"Cushioning Materials for the Protection of Furniture"—John Hoffman, Kimberly–Clark Corp.

"Packaging of Shipments of Furniture by Rail"—J. C. Anderson, Southern Weighing and Inspection Bureau

"Fiberboard Furniture Packages"—J. D. Evans, The Mengel Co.

Discussion: Review of Past and Future FPRS Packaging Committee Activities—Moderator—K. W. Kruger

Session XIV—Improved Plywood Products Through Technology

2:00 p.m. Thursday, June 7: East Ballroom, George Vanderbilt Hotel. Chairman: H. O. Fleischer, U. S. Forest Products Laboratory. Presiding Chairman: D. Nichols, Valdosta Plywoods, Inc., Valdosta, Ga.

"The Care and Maintenance of Veneer Knives"—N. Bowditch, Simonds Saw and Steel Co.

"Engineering Design of a Veneer and Plywood Plant"—E. H. Merritt, Lockport, N. Y.

"Maintenance of Quality in the Manufacture of Molded Plywood"—R. A. McKay, Brunswick-Balke-Collender Co.

"Investigating Rotary Veneer Cutting With the Aid of a Tension Test"—Eero Kivimaa, The State Institute for Technical Research, Helsinki, Finland.

Timetable of Events

Time	SUNDAY, JUNE 3	MONDAY, JUNE 4	TUESDAY, JUNE 5	WEDNESDAY, JUNE 6	THURSDAY, JUNE 7
7:30 a.m.		Authors' Breakfasts—Battery Park and George Vanderbilt Hotels	Authors' Breakfasts—Battery Park and George Vanderbilt Hotels	Authors' Breakfasts—Battery Park and George Vanderbilt Hotels	Authors' Breakfasts—Battery Park and George Vanderbilt Hotels
8:30 a.m.-12:00 Noon				Registration—City Auditorium Lobby	
8:30 a.m.-5:00 p.m.					Registration—City Auditorium Lobby
8:30 a.m.-5:30 p.m.		Registration—City Auditorium Lobby	Registration—City Auditorium Lobby		
9:00-10:00 a.m.		Executive Board Press Conference—Sun Dial Room, George Vanderbilt	Subject Matter Committees: Wood Preservation—Pisgah Room, Battery Park Hotel Industry-Education—Rhododendron Room, Battery Park		
9:00 a.m.-12:00 Noon		Technical Session I—Quality Control—City Auditorium Technical Session II—Wood Preservation—Gold Room, Battery Park		FPRS Suppliers' Exhibit—City Auditorium Technical Session IX Wood Machining—City Auditorium Technical Session X—Logging and Milling—East Ballroom, George Vanderbilt Subject Matter Committees: Glues and Gluing—Rhododendron Room, Battery Park Chemical Utilization—Sun Dial Room, George Vanderbilt Wood Drying—Vanderbilt Room, George Vanderbilt	Technical Session XI—Composition Board—Sun Dial Room, George Vanderbilt Technical Session XII Wood Finishing—East Ballroom, George Vanderbilt Subject Matter Committee: Logging and Milling—Pisgah Room, Battery Park
10:00 a.m.-4:30 p.m.	Executive Board Meeting Sun Dial Room, George Vanderbilt	FPRS Suppliers' Exhibit—City Auditorium, Ground Floor	Exhibitors' Day FPRS Suppliers' Exhibit—City Auditorium, Ground Floor		FPRS Suppliers' Exhibit-City Auditorium, Ground Floor
10:30 a.m.-12:00 Noon		Ladies' Get-Acquainted Hour—East Ballroom, George Vanderbilt			
11:00 a.m.-12:00 Noon			FPRS Business Meeting-East Ballroom, George Vanderbilt		
12:15-2:00 p.m.			FPRS Official Luncheon—City Auditorium		Section Officers' Advisory Committee and Executive Board Luncheon—Rhododendron Room, Battery Park
1:30-9:30 p.m.				Trip to Cherokee Indian Reservation, Great Smoky Mountains, Paul Bunyan Barbecue—Buses leave O'Henry Ave.	
2:00-5:00 p.m.		Technical Session III—Wood Preservation—Gold Room, Battery Park Technical Session IV—Marketing—City Auditorium Technical Session V—Glues and Gluing—East Ballroom, George Vanderbilt Subject Matter Committees: Quality Control—Sun Dial Room, George Vanderbilt Veneer and Plywood—Rhododendron Room, Battery Park	Technical Session VI—Glues and Gluing—East Ballroom, George Vanderbilt Technical Session VII—Wood Drying—Gold Room, Battery Park Technical Session VIII—Chemical Utilization—Pisgah Room, Battery Park Subject Matter Committee: Marketing—Sun Dial Room, George Vanderbilt		Technical Session XIII Packaging—Gold Room, Battery Park Technical Session XIV—Veneer and Plywood—East Ballroom, George Vanderbilt Subject Matter Committees: Composition Board—Tropical Room, George Vanderbilt Wood Finishing—Sun Dial Room, George Vanderbilt Wood Machining Grove Room, Battery Park
2:30-5:30 p.m.		Ladies' Tea and Children's Party—Grove Park Inn	Ladies' Trip to Biltmore Estate—Buses leave O'Henry Ave. Children's Movie Party		
2:30-6:00 p.m.	Registration—City Auditorium Lobby				
5:30-8:30 p.m.	Host Hour Sponsored by Carolinas-Chesapeake Section—East Ballroom, George Vanderbilt				
6:00-10:00 p.m.					FPRS Annual Banquet and Party—City Auditorium Children's Party
6:30-10:00 p.m.			Past Presidents' Dinner—Grove Park Inn.		
7:30-10:00 p.m.	Committee Meetings: Employment—SunDial Room, George Vanderbilt National Membership—Tropical Room, George Vanderbilt Publications—Grove Room, Battery Park	Command Performance of Play "Tight Britches"—William Randolph School Auditorium	Meetings: Subject Matter Committee Chairmen—Pisgah Room, Battery Park Section Officers—Sun Dial Room, George Vanderbilt		

FRIDAY, JUNE 8—8:30 a.m.—5:30 p.m.: Plant tours of ten wood-using industries in Asheville area.

MEET THE AUTHORS, CHAIRMEN, COMMITTEE MEMBERS FOR FPRS 10th NATIONAL MEETING

More than 150 persons are contributing to the success of FPRS Tenth National Meeting, serving as authors, session chairmen, and on committees. Latest technical advances in the wood industry will be reported in 14 technical sessions with more than 60 papers. Meetings of 12 FPRS Subject Matter Committees are also open to all registrants. Exhibits by 70 wood industry suppliers will consist of representative displays of raw materials and equipment used in the production of wood products.

E. ABRAMS

J. C. ANDERSON

I. J. BARBER

A. C. BAREFOOT

W. M. BEAVER

W. L. BELVI

F. BENDER

R. H. BESCHER

J. S. BETHEL

R. F. BLOMQUIST

C. C. BOOTH

R. R. BOTTOMS

N. BOWDITCH

D. L. BRINK

B. S. BRYANT

R. C. BUCHHOLZ

G. J. CARR

L. J. CARR

R. M. CARTER

M. B. CHRISTIAN

L. P. CLERMONT

J. COLUCCI, JR.

J. COUFAL

P. H. W. CR EN

W. J. DAMTOFT

E. L. DEMMON

P. F. DeSAIX

L. E. DOWD

J. B. DOUGHTY

L. D. ESPEN

D. EVANS

W. J. FINNORN

S. W. FREEMAN

H. O. FLEISCHER

R. C. GARRISON

A. S. GREGORY

R. J. HADER

D. A. HAILE

E. S. HARRAR

J. F. HARRIS

I. HATFIELD

J. B. HAYWARD

S. HENRIKSSON

D. E. HERRICK

G. M. HILL

W. C. HITCHINGS

J. A. HOFFMAN

R. J. HOYLE, JR.

M. S. HUDSON

W. L. IRWIN

E. P. IVORY

E. S. JOHNSON

F. H. KAUFERT

A. J. KIRSCH

E. KIVIMAA

P. KOCH

R. J. KOWAL

K. W. KRUGER

P. H. KRUPP

H. T. LARMORE

C. LATIMER

R. G. LENOX

R. M. LINDGREN

E. G. LOCKE

H. A. LOCKEMER

W. K. LOUGHBOROUGH

H. J. LOUGHEAD

D. G. LUBECK

A. A. MARRA

G. G. MARRA

M. H. MATER

J. S. MATHEWSON

J. W. MAXWELL

W. E. McCRAW

R. A. McKAY

W. L. MEEK

E. H. MERRITT

S. M. MILLE

W. K. MURPHEY

D. E. NICHOLS

N. A. NORTON

W. Z. OLSON

R. E. PALMER

A. J. PANSHIN

R. B. PARKER

L. A. PATRONSKY

I. A. PEARL

W. E. PRATT

S. B. PRESTON

R. B. PUTMAN

A. RAPAVI

H. B. REED

L. O. REED

M. J. RHUDE

D. B. RICHARDS

R. B. ROBERTSON

A. S. RYAN

J. F. SAEMAN

N. T. SHELTON

F. C. SIMMONS

F. G. W. SMITH

W. R. SMI

M. W. R. SMITH

R. C. SPROULL

M. A. TARAS

A. S. TODD, JR.

T. R. TRUAX

R. G. VANALLEN

J. B. VEACH, SR.

J. B. VEACH, JR.

A. F. VERRALL

C. S. WALTERS

R. F. WEBER

R. T. WHITE

B. M. WITHEROW

R. A. WOOD

W. J. WORTH

A. E. WYLIE

R. H. YALE

B. ZOBEL

SUPPLIERS WILL BE HOSTS FOR BARBECUE

FPRS Salutes Sponsors of Paul Bunyan Barbecue

More than 50 firms supplying materials and services to the wood industry have helped underwrite the cost of the Smoky Mountains Tour and Paul Bunyan Barbecue, to be held Wednesday, June 6, as an entertainment highlight of the Tenth National Meeting. These firms invite FPRS registrants and their families to be their guests for a full afternoon of sightseeing on a 130-mile trip through the Smokies, climaxed by the southern-style barbecue and entertainment in the evening. The list of sponsors as of May 1 included:

American Cyanamid Co., Charlotte, N. C.
American Cyanamid Co., New York
American Manufacturing Co., Tacoma, Wash.
Auto-Soler Co., Atlanta, Ga.
Bauer Bros. Co., Springfield, Ohio
Beh Manning Co., Troy, N. Y.
Bla Brothers Co., Inc., Mendota, Ill.
The Borden Co., New York
Carborundum Co., Niagara Falls, N. Y.
Ca n Corp. of America, New York
Chapman Chemical Co., Memphis, Tenn.
Chipcraft, Inc., Morristown, Tenn.
Coe Manufacturing Co., Painesville, Ohio
Peter Cooper Corp., Gowanda, N. Y.
DeLuxe Saw & Tool Co., Louisville, Ky.
Henry Disston Div., H. K. Porter Co., Philadelphia, Pa.
Hitchcock Publishing Co., Wheaton, Ill.
Jenkins Woodworking Machinery Div., Curt G. Joa, Inc., Sheboygan Falls, Wis.
Kennametal, Inc., Latrobe, Pa.
Kirk & Blum Manufacturing Co., Cincinnati, Ohio
Koppers Co., Inc., Pittsburgh, Pa.
The Lilly Co., High Point, N. C.
Masonite Corp., Chicago, Ill.
Miller-Hofft, Inc., Richmond, Va.
National Casein of N. J., Riverton, N. J.
Nelsonite Chemical Products, Inc., Grand Rapids, Mich.
Norment & Lambert, Inc., Lenoir, N. C.
Pacific Lumber Co., Chicago, Ill.
Perkins Glue Co., Lansdale, Pa.
Protection Products Manufacturing Co., Kalamazoo, Mich.
Raybond Electronics, Inc., Newton-Highlands, Mass.
Rockwell Manufacturing Co., Pittsburgh, Pa.
Simonds Saw & Steel Co., Fitchburg, Mass.
S. H. Smith Co., Publishers, Indianapolis, Ind.
Soderhamn Machine Manufacturing Co., Talladega, Ala.
Solem Machine Co., Lockport, N. Y.
Southern Screw Co., Statesville, N. C.
Standard Dry Kiln Co., Indianapolis, Ind.
Synvar Corp., Wilmington, Del.
Timber Engineering Co., Washington, D. C.
U. S. Plywood Corp., New York
Wilco Machine Works, Memphis, Tenn.
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo.
Yates-American Machine Co., Beloit, Wis.
Redman Engineering Service, High Point, N. C.

FPRS SUPPLIERS EXHIBIT IS COMPLETE SELLOUT

More than 70 firms and educational institutions have reserved space in the 95-booth FPRS Suppliers' Exhibit being held in conjunction with the Tenth National Meeting in Asheville June 4–7. Originally planned to contain 72 booths, announcement of the exhibit brought overwhelming industry response and plans were revised to enlarge the exhibit area to the full 14,000 square feet on the ground floor of the Asheville City Auditorium.

Tuesday, June 5, has been designated FPRS Exhibitors' Day, with technical sessions scheduled in the afternoon only, to give meeting registrants ample opportunity to visit all exhibits. The exhibits will be open throughout the week at the following times: Monday, June 4: 10 a.m.—4:30 p.m.; Tuesday, June 5: 10 a.m.—4:30 p.m.; Wednesday, June 6: 9 a.m.—12 noon; and Thursday, June 7: 10 a.m.—4:30 p.m.

The following indicates booth assignments, exhibitors, principal products, and booth attendants:

1. U. S. Forest Products Laboratory, Madison, Wis.; Research; F. J. Champion, Information Specialist

2 & 3. The Lilly Co., High Point, N. C.; Finishes; R. I. Quigley, Vice-President

4. Durez Plastics Div., Hooker Electrochemical Co., N. Tonawanda, N. Y.; Resins; H. Puff, Tech. Rep.

5. Kennametal, Inc., Latrobe, Pa.; Carbide Tools; Rex Reynolds

6. The Dean Co., Chicago, Ill.; Chipcore; T. J. Connelly, Pres.

7. U. S. Plywood Corp., Charlotte, N. C.; Novoply and Plywood Products; Carl W. Justice, Branch Manager

8. Wel-Dri Co., Memphis, Tenn.; Dry Kilns; W. L. Wellford, Jr., President

9. Marietta Paint & Color Co., High Point, N. C.; Finishes; R. W. Beaver, Supt.

10. Woodwelding, Inc., Burbank, Calif.; High Frequency Heating Equipment; Jack Cunningham, Pres.

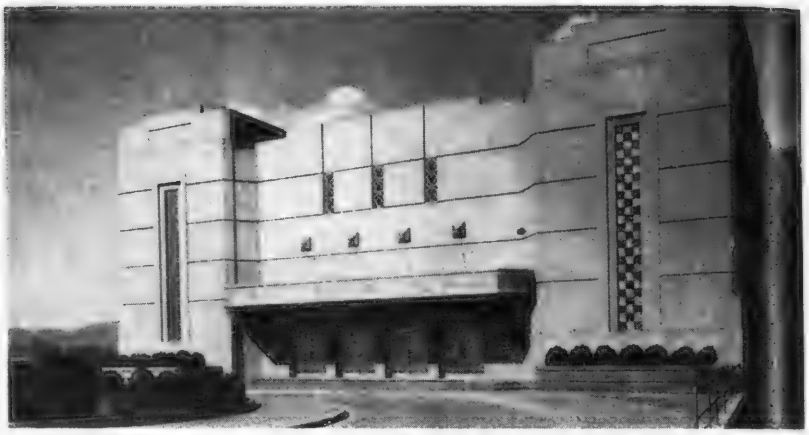
12. W. F. Meyers Co., Bedford, Ind.; Carbide Saws & Tools; L. Frank, Sales Dept.

13. Information Booth

14 & 15. Weyerhaeuser Sales Co., St. Paul, Minn.; Hardboard & Chipcore; R. Miller, Mgr., Sales, Hardboard Dept.

16. United-Carr Fastener Corp., Cambridge, Mass.; Furniture Gliders, etc.; J. Ring, Assistant Advertising Manager

18. Williams Patent Crusher & Pulverizer Co., Inc., St. Louis, Mo.; Chippers; E. M. Carson, Assistant Secretary



Asheville City Auditorium, headquarters for Tenth National Meeting, will be location of FPRS Suppliers Exhibit and key technical sessions.

19 & 20. Deluxe Saw & Tool Co., Louisville, Ky.; Carbide Tools; A. G. Feldmann, General Manager

21 & 22. E. I. duPont de Nemours & Co., Wilmington, Del.; Finishes; W. D. Woods, Assistant Industrial Sales Manager, Finishes Division

23. Hardwood Corp. of America, Asheville, N. C.; Dimension Lumber; J. B. Veach, President

24. Williams-Brownell, Inc., Asheville, N. C.; Veneers, etc.; J. B. Veach, President

25-27. Wilco Machine Works, Memphis, Tenn.; Hot Presses & Woodworking Equipment; R. Wilson and Dan Copp

28. Cleworth Publishing Co., Greenwich, Conn.; Industrial Woodworking magazine; J. H. Goodenough

29. Perkins Glue Co., Lansdale, Pa.; Adhesives; L. E. Clark, Technical Division

30. Miller-Hofft, Inc., Richmond, Va.; Chipcore Plants & Engineering; H. C. L. Miller, President

31. Cellu-Products Co., High Point, N. C.; Furniture Padding; Martin Doll, President

32. The Heil Co., Milwaukee, Wis.; Chip Drying Systems; D. E. Fricker

33. Carolina Forest Products Co., Wilmington, N. C.; John Colucci, Jr.

34 & 37. Moore Dry Kiln Co., Jacksonville, Fla.; Dry Kilns; Pat Williams, Jr.

35. Timber Engineering Co., Washington, D. C.; Research Facilities; E. R. Butler

36. The Bahnson Co., Winston-Salem, N. C.; Dehumidifying Equipment; J. C. Rose

38. Lustrewood Corp., Milford, Conn.; Prefinished Drawer Bottoms; R. Wilder

39. S. H. Smith Co., Indianapolis, Ind.; Woodworker & Veneers and Plywood magazines; J. F. Burrell, General Manager-Editor

40 & 41. National Adhesives, New York City; Adhesives; Joe Coufal and W. J. East

42. Allen T. Shepherd Co., Armstrong Machine Works, Three Rivers, Mich.; Steam Traps; A. T. Shepherd, Manager

43. Norment & Lambert, Inc., Lenoir, N. C.; Machinery Representatives, M. J. Lynch

45. Adamson-United Co., Akron, Ohio; Chipcore Machinery & Engineering, G. L. Fenn, Vice-President

46. Victory Carbide Saw & Tool Co., Chicago; Carbide Saws & Tools; C. Vanderwerker, Jr.

47 & 48. Dependable Machine Co., Greensboro, N. C.; Machinery; C. G. Monnett, Vice-President

50. Guilliet Co., Auxerre, France. Represented in U. S. by Council on Public Relations, New York City; Chippers

51. Binks Manufacturing Co., Chicago; Finishing Systems; C. E. Fuller, Sales Promotion Manager

52. Bramco, Inc., New York City; Chipcore Plants & Engineering; I. R. Louis, Vice-President

53. Steel Slides, Inc., Yonkers, N. Y.; Steel Furniture Slides; Leo Edelson, Vice-President

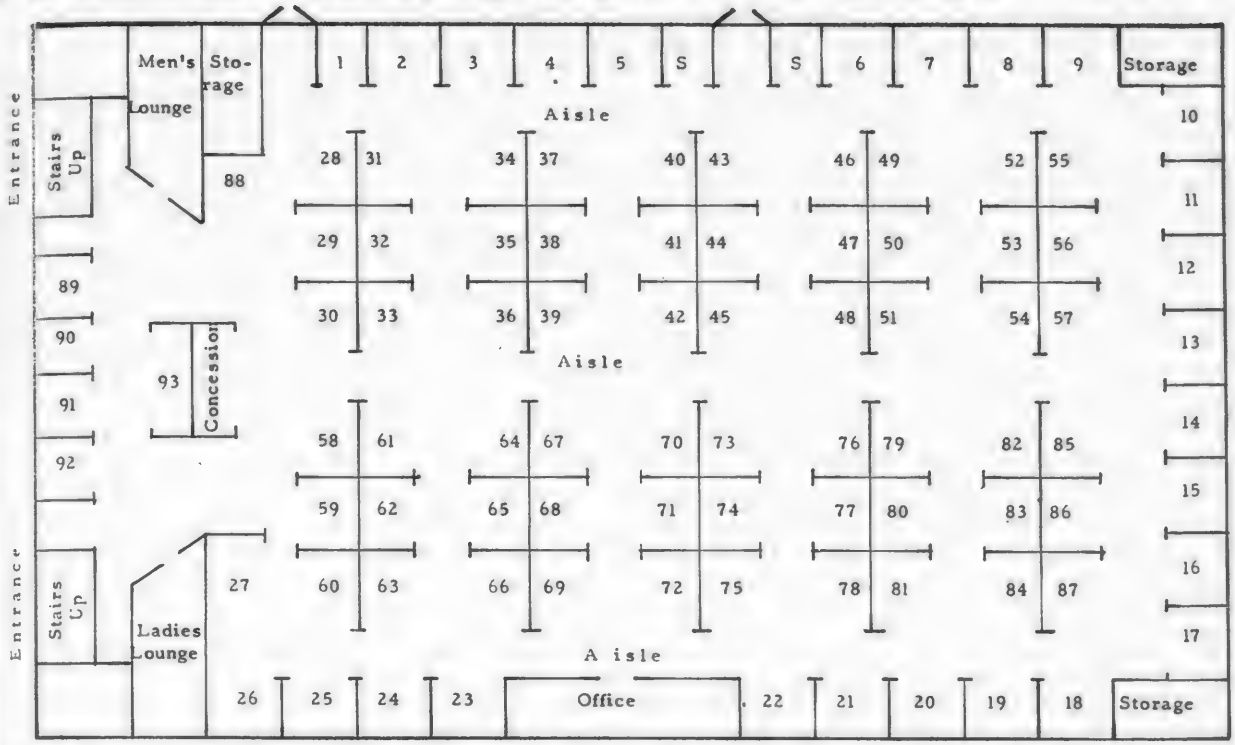
54. Simonds Saw & Steel Co., Middleburg, N. C., Carbide Saws & Tools; G. H. Atkins

55. American Cyanamid Co., Charlotte, N. C.; Adhesives & Resins; G. H. Melvin

56. Carboloy Dept., General Electric Co., Detroit; Carbide Tools; J. W. Mason, Mgr.

57. Catalin Corp. of America, Greensboro, N. C.; Adhesives & Resins; P. A. Krentel, Sales Mgr., Southeastern Division

Here's Your Handy Guide to 95-Booth Exhibit Area



58 & 59. Masonite Corp., Chicago; Hardboard Products; C. E. Sutton, Sales Promotion Manager

60. R. T. Vanderbilt Co., Inc., New York City; Lumber Seasoning; K. S. Karsten

61. Reichhold Chemicals, Inc., Charlotte, N. C.; Adhesives & Resins; Thomas Johnson

62. Chipcraft, Inc., Morristown, Tenn.; Chipcore Systems; J. M. Crafton, President

63. Standard Dry Kiln Co., Indianapolis, Ind.; Dry Kilns; R. H. Elliott, Vice-President

64. R. Hoe & Co., Inc., High Point, N. C.; Carbide Saws & Tools; R. D. Brooks, Mgr., Carbide Saw & Tool Division

65. Drexel Furniture Co., Drexel, N. C.; Chipcore; G. M. Hill, Vice-President and Director

66 & 69. Onsrud Machine Works and Onsrud Cutter Mfg. Co., Chicago; Woodworking Machinery & Cutterheads; R. M. Miller, Sales Mgr., Woodworking Machinery Division

67. Power-line Sales, Inc., Detroit; Stapling Machinery; J. E. Hart, Sales Mgr.

70 & 73. National Casein Co., Riverton, N. J.; Adhesives; R. J. Thomas

71. Mall Tool Co., Chicago; Portable Power Saws & Tools

72. Jenkins Machinery Div., Curt G. Joa, Inc., Sheboygan Falls, Wis.; Woodworking Machinery; G. F. Kiela, General Mgr.

75. National Cylinder Gas Co., Chicago; Wood Preservatives; E. L. Russell

76 & 79. Franklin Glue Co., Columbus, Ohio; Adhesives; L. T. Williams

77, 78, 80, 81. Raybond Electronics, Inc., Newton-Highlands, Mass.; High Frequency Heating Machinery; O. Racoosin, Pres.

82 & 85. Spotnails, Inc., Evanston, Ill.; Nailing Machinery; C. W. Babcock, Vice-President

83. Decar Plastic Corp., Middleton, Wis.; Decorative Laminates; T. W. Noble, Technical Director

84 & 87. The Borden Co., New York City; Adhesives; J. S. Brown

86. Tri-State Container Corp., Elizabethtown, Tenn.; Containers; A. C. McDonald, Jr., Sales Mgr.

88. Southeastern Forest Experiment Station, Asheville, N. C.; Research; W. R. Smith, Chief, Forest Utilization Service

89. University of Michigan, Ann Arbor; Education and Research; S. B. Preston

90. Alabama Polytechnic Institute, Auburn; Education and Research; D. B. Richards

91. Michigan State University, East Lansing; Education and Research; A. J. Panshin

92. Pennsylvania State University, University Park; Education and Research; Newell A. Norton

93. N. C. State College, Raleigh; Education and Research; J. S. Bethel

93. Duke University, Durham, N. C.; Education and Research; E. S. Harrar

S1. State University of New York College of Forestry, Syracuse; Education and Research; H. B. Gatslick

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Send for Your FPRS Lapel Pin And Membership Certificate Now

Buy and wear an FPRS lapel pin. It will identify you as an active supporter of wood industry research and progress. The attractive green and gold pins are available for 75 cents. For an additional 25 cents, you can receive 8 x 10 frameable membership certificate. Send your order to Executive Secretary, Box 2010, Univ. Station, Madison 5, Wis.

Cover Photo:

Meet Ralph Bescher, FPRS' Next President

ONE HOT SUMMER afternoon many years ago, a small boy was sitting on the back porch swing of his home in Dayton, Ohio. As he likes to recall it now, a portly—and very industrious—neighbor lady came in from her back yard garden and in passing said to him, "Son, it's just a little too hot in the sun for hoe-in' corn—I reckon I'll come in and pick cherries in the shade!"

The boy was Ralph Henry Bescher, and he has always remembered this as his first lesson in diligence. Since that time, he himself has been hoeing a lot of corn—and picking some cherries, as well.

On June 5, Ralph Bescher will be installed as President of FPRS during the 10th National Meeting in Asheville, N. C. This is something of a milestone in a career already studded with bench marks of accomplishment.

A Man with Responsibility

From his office on the seventh floor of Pittsburgh's Koppers Building, Ralph Bescher carries out his numerous duties with the Koppers Company's sprawling Wood Preserving Division. Although his responsibilities as Assistant to the General Manager of the Division are considerable, he keeps his door open to visitors and answers his own phone. Callers who can get only his secretary may be certain that Ralph is in California, or Alabama—or even Guatemala.

Affable Ralph Bescher has an easy-going manner that cloaks an industriousness and determination shared by few others. A charter member of FPRS, he served on the Executive Board as North-Central Regional Board member from 1949–52 and was General Chairman of the Sixth National Meeting in Milwaukee in 1952. He was Vice-President in 1954–55 and became President-Elect in 1955. Besides assuming the presidency at the Asheville meeting, Ralph is serving as technical program chairman.

In addition to his many FPRS activities, he has been prominently associated with the American Wood Preservers' Association, serving as its President in 1953. He is also an active member of the American Society for Testing Materials, American Chemical Society, American Railway Engineering Assoc., National Fire Protection Assoc., National Security Industrial Assoc., and the government's National Research Advisory Board.

Like as not, Ralph will be found in the councils' of these organizations, proposing improvement of building codes, promoting the more widespread use of pressure-treated wood, or pursuing what has been so far his elusive bluebird—revised insurance standards for fire-retardant wood. "After all," he reiterates, "when you can treat wood so it won't burn—that's news!"

A Man of Perseverance

To get where he is today, Ralph Bescher has tugged at his own bootstraps all the way. After graduating from Dayton's Steel High School, he helped pay his way through the University of Cincinnati by working first as a laborer for Mead Pulp and Paper Company and then for four years as a lab assistant for Beckett Paper Company. He graduated from Cincinnati in 1930 with a degree in chemical engineering.

The turn of the 1930's was also something of a turning point for Ralph Bescher. Within a year he had joined the Wood Preserving Division of Koppers at the Orrville, Ohio, treating plant, and had married a comely young lady named Ann Caserta. He has lived and worked for both ever since.

From his work as a chemical engineer at Orrville, Ralph earned steady promotions. He was successively Chief Chemist, Assistant Manager, Technical Department, and finally, Manager. In 1954, he was transferred to the General Offices in Pittsburgh and made District Manager, Pittsburgh Sales District. His most recent promotion to Assistant to the Division General Manager came in April, 1955.

When he isn't carrying on business at one of his familiar stands, Ralph Bescher finds his relaxation in the activities of his wife and four children, or in puttering with his hobbies of photography and gardening. His camera is a constant accoutrement to his business trips, and he takes countless pictures when he is on the road. As he puts it, though, his albums are filled mostly with pictures of utility poles, highway guard rails, and stands of timber.

Just another case of picking cherries in the shade!

Three Men Completing Executive Board Terms

New officers will be installed during the annual FPRS Business Meeting, June 5, with three men completing terms on the Executive Board.

Moss B. Christian, President for the past year, will continue on the Board as Past President. He has been a Society officer since 1949. During his term as President, membership has increased 10 per cent and is now over 3,100.

Past President Lester J. Carr is completing seven years' service on the Board. He was Southwest Regional Board Member, 1949–52; Vice-President, 1952–53; President-Elect, 1953–54; and President, 1954–55.

W. Jeter Eason, South-Central Regional Board Member for three years, is a candidate for Vice-President this year. He served as General Chairman of the 1953 National Meeting in Memphis, was formerly Chairman of the Mid-South Section.

E. S. Harrar, Southeast Regional Board Member since 1953, is serving as General Chairman of the 1956 National Meeting. He was Chairman pro tem during the organization of the Carolinas–Chesapeake Section and later served as Trustee and Secretary-Treasurer of this Section.

FOREST PRODUCTS RESEARCH SOCIETY OPERATING STATEMENT—F.Y. 1956
4/1/55–12/31/55

Cash and Savings and Loan Stock			$22,670.15
Receipts:			
1955 Membership Dues	$ 3.00		
1956 Membership Dues (F.Y.)	21,350.13		
1956 Membership Dues (C.Y.)	916.75		
Dues Collected for Sections	2,482.00	$24,751.88	
Publications Income		19,511.20	
Other Income:			
Anchor Dividend	$ 150.00		
Service to Sections	499.23		
Miscellaneous	115.50	764.73	
Executive Office Building Contributions		400.00	
1955 National Meeting		155.15	
North Central Regional Meeting		336.03	45,918.99 $68,589.14
Expenditures:			
Central Office Expense:			
Salaries	$21,529.24		
Supplies, Equipment, Utilities, etc.	8,941.25		
Staff Travel	2,090.94	$32,561.43	
Executive Board Expenses		115.75	
Executive Office Building Taxes, etc.		790.27	
Publications Expense		22,715.55	
North Central Regional Meeting		336.03	
1955 National Meeting		367.50	
1956 National Meeting		800.00	
Section Dues Remittances		4,682.00	
Services to Sections		343.36	62,911.89
Cash and Savings and Loan Stock			$ 5,677.25

NOTE: This statement does not reflect additional amounts of $20,729.72 prepaid dues and $[illegible] prepaid Section remittances prior to 4/1/55, bringing the total actual receipts to $68,940.70 and the year-end balance in Cash and Savings and Loan Stock to $28,698.97.

Thermatron bonded panels 120" x 10" come from the press at Bally Block Co. in three minutes—yet the old method required at least three hours just for the glue to set. Then each hand clamp had to be loosened to remove the panels. Incidentally, the space needed to handle the seven short panels shown in the bottom picture is just about the space taken up by the new Thermatron electronic equipment which gives many times more production.

Edge Bonding at Bally Block Co. now a fast, streamlined operation with THERMATRON electronic equipment

Bally Block Co., Bally, Pa., required volume production of edge bonded panels—which they get now with their powerful new 20 KW Thermatron radio frequency generator and hydraulic press installation.

The equipment easily accommodates stock 6 inches thick and 8 feet long, while longer panels are handled progressively. Once fed into the press, they receive an electronic "jolt" and the bond becomes stronger than the wood itself.

There's an extra, too. Bally Block found that large storage areas once given over to glue drying are now released for production instead. This gives them far more payload per factory foot.

Let us show you without obligation how modern methods can speed *your* wood bonding operation and achieve vast savings. Thermatron equipment is available up to 300 KW in all degrees of automation to suit your special purpose. Please request a copy of our latest bulletin FP 11.

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YOUR GUIDE TO *Better* ADHESIVES . . .

The Perkins Trade Mark is your guarantee of quality and reliability when you purchase glues. Since 1899, customer-confidence in Perkins has grown steadily—a deserved tribute to superior products backed by competent service and rigid ethical standards. When you use a Perkins Glue in your operations, you'll agree with other leading woodworkers—*that Perkins serves you best!*

GLUING PROBLEMS?

Dispose of them by calling upon the skilled assistance of the Perkins Technical Service Department. Specialists in gluing methods will study your particular operations and offer suggestions where pertinent. There is no cost or obligation involved in your use of this unbiased advice.

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CASEIN—A broad line to meet your specific requirement
VEGETABLE—As originated and perfected by Perkins Glue Co.
ANIMAL—Ready-to-use Liquid • Heat-then-use Gel

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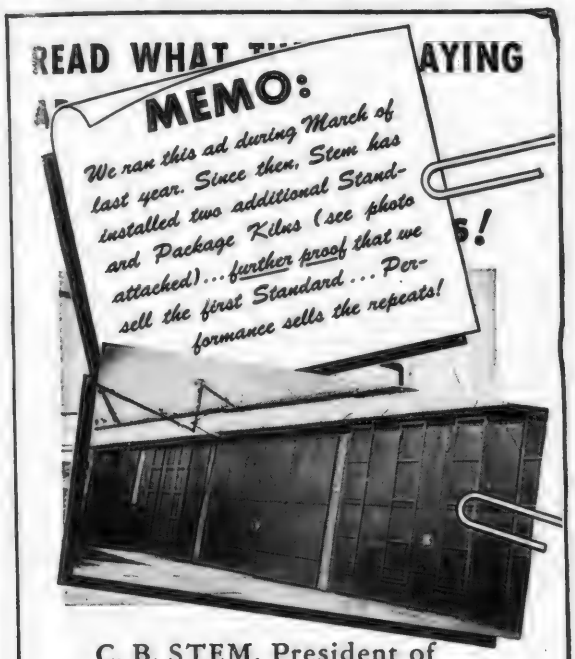
VENEER AND CORE REPAIR COMPOUNDS • VENEER SIZE
GLUE ROOM SPECIALTIES • MIXERS • SPREADERS • BRUSHES

RESIN CASEIN **PERKINS** VEGETABLE GLUES

ESTABLISHED 1899

LANSDALE, PA. KITCHENER, ONT.


READ WHAT
AYING
MEMO:
We ran this ad during March of last year. Since then, Stem has installed two additional Standard Package Kilns (see photo attached)... further proof that we sell the first Standard... Performance sells the repeats!

C. B. STEM, President of

CHESTER B. STEM, INC.

Manufacturers of

VENEERS AND LUMBER

AMERICAN WALNUT—WHITE OAK—MAHOGANY

NEW ALBANY, INDIANA

Writes: "We are glad to report that we have had very satisfactory service from our STANDARD package kilns. So much so that we are now ordering a third and larger kiln from you. In the 3½ years we have used STANDARD kilns, we have kiln dried a great deal of expensive lumber such as Walnut, rift Oak, quartered Oak, Honduras Mahogany, African Mahogany, Cherry, etc. We can truthfully say we have had no difficulties whatsoever and we have received no complaints from any of our customers concerning lumber dried in these kilns. That in itself should tell the whole story."

Write for free illustrated Standard Catalog

Manufacturers of Internal Fan Kilns

STANDARD

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BRANCH OFFICE: REDMAN ENGINEERING SERVICE • HIGH POINT, N. C.

Not How Much But How Well

IT HAS BEEN A PRIVILEGE to serve as your president for these past twelve months and witness the Society's continued growth both in membership and stature. As I try to evaluate our progress, I am reminded of a philosophy, variations of which you have heard many times over. It is that "the true measure of success is not how *much* but how *well*."

M. B. Christian

It is not how many new members we attract but how well we serve our entire membership that counts.

How much income we develop is not nearly so important as the uses to which we put it.

How many meetings we hold or pages we publish is insignificant beside the point of how much good these efforts have accomplished.

In the final analysis, only you, the member, can truly measure how successful or unsuccessful this past year has been for FPRS.

For example, has the FOREST PRODUCTS JOURNAL helped to answer questions relating to your, or your company's, daily operations? Has publishing it monthly rather than bimonthly improved your ability to absorb or locate such information? Is the JOURNAL publishing a fair share of the kind of information you need?

Has your local Section provided you with good technical programs as frequently as you would like and on subjects about which you have a desire to learn more?

Have your letters to the Society's Executive Office, either in regard to membership problems or technical questions, been answered promptly, courteously, and in an effort to be genuinely helpful?

Have you had occasion to use FPRS' informal employment services? If so, do you feel that your individual inquiry was handled with care and consideration?

If we can answer these and similar questions in the affirmative, then we have had a successful year. Only you can be the judge.

May I take this opportunity to thank every person on committees, in Sections, and my Executive Board, with whom I have worked in the past year, for your splendid cooperation.

MOSS B. CHRISTIAN, *President*

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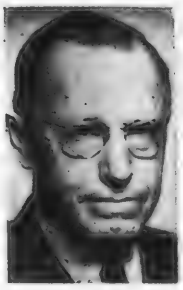

Ten Years of FPRS Progress and A Look Ahead[1]

GEORGE M. HUNT

TEN YEARS AGO, a small group of men met in Madison to form an association that would stimulate discussion and hasten progress in forest products research and utilization. It would be open to everyone interested in any phase of forest products research and development. If my recollection is correct, there were only 13 in that first group; others had been invited but were unable to attend. William J. Baker acted as Secretary-Treasurer and Bror Grondal as temporary Chairman. The general plan of the association was agreed upon, but the innumerable details necessary to its functioning were left for subsequent committee action and general balloting after the membership became larger. Each man present then deposited his ten dollar membership dues and the Forest Products Research Society was in business.

Like any new-born infant, however, the Society needed a great deal of friendly care and guidance and its energies had to be spent entirely in growing and in trying to keep out of trouble. Baker continued for some months to be the Secretary-Treasurer, without compensation, and spent practically all his off-duty hours on the task. One of his first problems was to determine who of that first group of 13 should receive membership card number one. When it was decided that the only fair way was to distribute membership numbers to this group alphabetically, he was pleased to find that it gave him number one. It was not long before the work of the Secretary-Treasurer became too heavy for voluntary help and a paid executive was employed on a part-time basis. Later a full-time Secretary-Treasurer became necessary with a staff, several offices, and much equipment.

Remarkable Growth

The growth of FPRS and its accomplishments since that first meeting ten years ago have been remarkable. Then we were nothing but an idea. Today we are a vigorous organization of over 3,200 members in 31 countries. We have 12 local sections in the United States and 1 in Canada. We started with $130. Our budget last year was $80,000. Size of budget and number of members, however, do not necessarily indicate the value or usefulness of an organization. The usefulness of an organization is measured by what it accomplishes. The Forest Products Research Society, after ten years of activity, can confidently stand up to be measured by that yardstick.

Here are some of the useful things we have done and are continuing to do that benefit not only the members of the Society but the public in general: We have provided a means of bringing together all the different elements concerned in any way with the production, investigation, distribution, and utilization of the products of the forest. We are in no way a substitute for professional societies or trade organizations but a means through which these groups can work together on matters of common interest. We are, as has been said before, a horizontal organization cutting across the professional and trade organizations, which may be considered vertical organizations, and bringing together for a common purpose their energies, skills, and interests.

We have provided a means of publishing the thoughts and the findings of all who are concerned with forest products, whether the material to be published relates to chemistry, engineering, electronics, education, business management, or any other subject. The only requirements are that the material shall relate to some phase of the Society's field of interest, shall be well written, and shall be useful. We have already, through our publications, provided a storehouse of useful information that has reached the shelves of libraries throughout the world and is being studied and cited with increasing frequency.

Stimulated Cooperation

We have aroused the interest of many companies and individuals and stimulated them to work more actively and aggressively for the advancement of our common interests. We have brought research and industry closer together in our field and this contact has given to each a greater respect and consideration for the other.

We have provided local sections so that members in different parts of the United States and Canada can get together at frequent intervals for discussion of problems of regional or local interest. Perhaps, some day, we will have sections in other countries. This encourages the participation of many individuals who cannot attend the annual National Meeting.

We have, in short, far exceeded our greatest hopes for our first ten years because of the wisdom, foresight and efforts of our local and national officers, our progressive members, and the effective activities of our expert headquarters staff.

The next ten years, I am sure, will bring greater advancements because science and technology are progressing at an accelerated rate, new markets and opportunities are opening, new processes will be developed, and new products will be needed. The Forest Products Research Society will continue to be in the thick of these developments as a stimulator and catalyst. It will also continue to provide forums for discussion and publish the records. I feel certain that its membership, its activities, its usefulness, and its prestige will grow at a faster rate than the normal increase in business activity that must accompany our growing national population. I suggest that you check on this forecast in 1966.

The Author: George M. Hunt, former director of the U. S. Forest Products Laboratory, attended Willamette University and holds a B.S. degree from the U. of California. He entered the Forest Service in 1911, transferred to the Forest Products Lab in 1913. Mr. Hunt was chief of the Wood Preservation Division from 1919–44; Assistant Director of the Laboratory, 1944–48; and Director, 1948–51. For the past two years he has been consultant to the Philippine government in establishment of a new Forest Products Laboratory in Laguna. A founder and charter member of FPRS, Mr. Hunt served as acting Secretary-Treasurer of the Society for several months in 1950.

National Products Engineer Represents Behr–Manning in FPRS

Behr-Manning Co., Troy, N. Y., has appointed Harvey L. Bennett, its national products engineer to the woodworking industry, as designated representative to FPRS. A division of Norton Abrasives, Behr-Manning has been a FPRS Company Supporting member for the past three years.

H. L. BENNETT

A graduate of Canisius College, Mr. Bennett joined Behr-Manning in 1948 and became a field engineer in the High Point, N. C., division. He later served two years as products and methods engineer in the southern region before his latest promotion in 1955.

The Troy firm is one of the largest manufacturers of coated abrasives, making more than 45 miles in an average day. It also manufactures a wide variety of pressure-sensitive tapes.

At Troy, Behr-Manning's Products Engineering Dept. has developed many advanced designs in coated abrasive machinery that have been adopted by machinery manufacturers and are now being used in the woodworking and furniture industries. Mr. Bennett co-ordinates and disseminates all woodworking information to the company's product and field engineers throughout the country.

Behr–Manning Co. produces more than 45 miles of coated abrasives in an average day.

In addition to its Troy laboratories, Behr-Manning Co., operates clinics at its 16 branches in major cities, where manufacturers may witness demonstrations of new machines and techniques, and receive counsel on production problems .

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Manufacture and Use of Wood Particle Board[1]

R. D. BIBBY[2]

William Mallinson Ltd., London, England; Former General Manager, The Lane Co., Altavista, Va.

Desirable characteristics for particle board are listed and various manufacturing processes described. Advantages and disadvantages of the processes are reported. Equipment and production costs are given for a horizontal extrusion process, as well as test figures for board manufactured by this system. Uses and machining of particle board are also discussed.

WOOD PARTICLE BOARD is a description which covers an extremely wide range of actual and possible products, with great divergence in particle size and type of binder used.

The particle size can be as fine as sawdust or may be as long and fibrous as excelsior. The particle may be produced by means of suitably screening existing waste material or it may be made specially by a variety of processes. In general, the two main types are those which are "chunky" with relatively high thickness/length ratios and those which are "flaky" and have low thickness/length ratio.

Some special boards combine both types of chips in a stratified construction. This may have some value if the board is to be used for decorative purposes, but otherwise does not seem to justify higher costs.

Where the initial waste or raw material is in the form of large pieces such as cordwood or peeler cores, it is possible to produce the specially made flakes or excelsior type fibres. Where general mill or machine room wood waste is the raw material, then such specially made flakes, etc. are not possible. In these cases the chips can be produced in a suitable chipper or hog. Careful selection of hog or chipper and careful maintenance thereof is necessary if a consistent type of chip is to be produced. Whichever type of particle is to be made, it is important that particle size and shape are closely controlled at all times.

[1] Presented at FPRS North-Central Region Meeting, Nov. 15–17, 1955, in Chicago, Ill.
[2] Read for Mr. Bibby by Don Collins, Development Engineer, Adamson-United Co., Akron, Ohio.

The Author: R. D. Bibby was educated in England, is professionally qualified as an engineer and accountant. During World War II, he was engaged in the production of prefabricated houses. In 1948 Mr. Bibby became General Works Manager of Harris Lebus Ltd., London, and in 1951 joined the The Lane Co., Altavista, Va., serving as General Manager, until Sept. 1955. He has been engaged in the study of wood waste products since 1944, having worked in Sweden and Switzerland on these projects.

Just as different species of solid lumber have varying characteristics, so does particle board made from different species of raw material. These natural differences can be modified by proper dispersion of binders and by maintaining an even mixture of waste so far as possible.

Binders such as gypsum, Portland cement, and various thermosetting resins are commonly used for wood particle boards. For particle board for general use in furniture, building, and decorating, as a substitute for solid lumber, it is usual to use a thermosetting resin binder. These may include urea-formaldehyde, cresol-formaldehyde, phenol-formaldehyde, melamine, or resorcinol types. For cheapest board, with adequate characteristics for indoor use, it is probable that urea-formaldehyde will continue to be used in the United States.

Resin dispersions ranging between 5% and 12% (dry weight) of the wood particles are used in varying processes for production of boards suitable for a lumber substitution. Most of these resins require a catalyst. The desirable catalyst permits a long pot life and fast cure at curing temperature. Precure of the resin will lead to process difficulties and a weaker board.

Desirable Board Characteristics

Wood particle board to be used as a substitute for lumber should have the following characteristics:

(a) Dimensional stability equal to the wood to be replaced
(b) Even density throughout its whole volume
(c) Good screwholding power
(d) Freedom from inherent warpage tendencies
(e) Machineability to produce a flat and stable surface for veneering or laminating
(f) Good compressive strength
(g) Reasonable flexure and modulus of rupture in bending
(h) Good shear strength
(i) Economic cost as compared with the lumber or plywood for which it is to substitute
(j) Good gluing properties
(k) Density not more than about 12% higher than the lumber replaced.

Available Processes

At present, there are three main processes for the production of wood particle board:

(a) Multi-platen press with or without pre-press
(b) Vertical extrusion press
(c) Horizontal extrusion press.

The multi-platen press (horizontal) was the first method used for production of chipboard and is still used in the manufacture of many available boards, including those of a laminated type which have a variety of chip size in different strata.

There are extreme difficulties in connection with the production of even density boards by this process. It is difficult to avoid uneven spread of chips and impossible to prevent some degree of settling of the fines to the lower face of the board. Even with a pre-press operation, which compacts the load before the application of final pressure and heat in the main press, it is almost impossible to avoid partial pre-cure.

The need to handle large boards from process to process in platen sizes (usually 4- by 8-foot or larger) makes for an expensive and space consuming layout.

The control of thickness with the multi-platen process is dependent upon the spread of an even layer of particles and the subsequent application of equal pressure between two parallel planes. This is almost impossible to achieve and most multi-platen boards show evidence of fairly wide variations in thickness or in density as they leave the press. These multi-platen processes which minimize thickness variations by means of stops between the platens

develop a tendency to greater variations in density than would otherwise be the case.

Wood particles and binder do not act in a fully fluid manner when under pressure. As partial cure of the binder proceeds, the departure from fluid behavior becomes greater.

In most cases the particles as laid in the spreader do not have a planar upper surface. Even when prepressed this characteristic is present in a degree. As the press platens are closing, the particles always take up a non-parallel orientation at first.

There is a large area of platen in contact with the chips or with the caul sheet. This area presents a considerable frictional resistance to sideways movement of the platens under pressure. As pressure is increased, so is the friction increased.

Under the combined influence of progressive curing of the binder and the increasing friction resulting therefrom, the condition wherein no amount of extra pressure will be adequate to bring the platens parallel may be soon reached and consequently a board of varying thickness and density is produced.

In most multi-platen processes it is not possible to make a board of normal or desired density and strength within about 3-inches of the edge of the board. This causes waste of materials and waste of capacity.

Economy demands that particle boards should be made with a fair degree of mechanization. This factor and the requirements of normal batch production result in several batches of board being at operation stages between the spreader and the output side of the press. Typically, such lots will exist:

(a) Between the spreader, pre-press and the press loader (part of a batch)
(b) In the press loader
(c) In the press
(d) Just discharged from the press and ready for inspection and sizing.

Though various methods of gauging and controlling chip spread have been and may be devised, the wood particles do not behave in an entirely consistent manner and ultimate control of density or thickness can be made only as a result of examination of the product emerging from the press. Even with the most efficient spreaders, each time there is a change in the desired thickness, density, or character of chip being supplied, final spread adjustment depends on a degree of trial and error.

The large amount of material in batches between the spreader and the press at any time makes for a considerable lag between the identification of a need for spread modification and its implementation. In many cases conditions may already have changed before the adjustment can be made. In such cases the adjustment made may be of the wrong degree or in the wrong direction.

On all installations examined to date, the capital costs, material costs, and running expenses of the multi-platen process are higher than any other.

The Extrusion Process

There are well established processes for the manufacture of particle board by the extrusion method. These processes are reputed to be well covered by patents pending and allowed.

One of these processes is the vertical extrusion method, which is well known as the Kreibaum process. Because of the well known tendency of multi-platen processes to cause the fines to sift to the lower surface of the board, it has been conceived that the production of a board which was built up in the vertical plane would eliminate this trouble and make the presence of "fines" less critical in the board. This objective is achieved in the vertical process, but there are unfortunately two disadvantages which may outweigh the advantage gained by this achievement.

The first of these disadvantages is that the fines, which in the multi-platen process would settle to the bottom side of the board, instead fall in layers to the bottom of each segment of the extruded board and so increase the tendency of segmentation and relative weakness of the board in the direction of extrusion as compared with at 90° to the direction of extrusion.

The second disadvantage is the tendency for nearly all of the chips to lay in planes vertical to the faces of the finished board. This is desirable if stability of thickness alone is considered, but is not so desirable from overall strength considerations.

Any extrusion process involves the feeding of the particles and binder through a heated die aperture, and the subsequent cutting off of the finished board to desired size as it leaves the die. For a fully cured board, which is to be cured by radiant heat, a long die aperture is necessary if high rates of output are required. (The use of radio-frequency dielectric heating for this purpose is covered by patents.) In the case of the vertical extrusion press, the length of the die aperture is limited by practical considerations of building and machine design height.

Height limitations can be met in part by causing the extruded board to describe a 90° arc after leaving the die and enter the cut-off saw on a horizontal plane. This means that the board can be cut off in any desired size but in order to describe the required arc, the board must be less than fully cured and must be of a thickness which will avoid excessive differences between the inside and outside radii of the curved board. It is possible that at about 1½ inches thick the limit of thickness of a reasonably strong board which was to be curved without defect, would be reached. Thicker boards will require to be cut off in the vertical plane and therefore there will be limitations to the length at which the board can be cut off.

Properly operated, the vertical extrusion process will produce a board which is adequate for all core purposes, and may be used for unveneered applications where the surface texture is good enough. To make a good board by the vertical extrusion process, it is possible that more attention than is commonly given to preparation of the particles is desirable. It may be necessary to revise ideas about the absence of screening equipment in some installations.

Another extrusion process is of the horizontal type which is used in the Lanewood press designed by the writer of this paper with the help of Mr. Don Collins of Adamson United Company, Akron, Ohio, who have undertaken the manufacturing arrangements for the press.

Because it is an extrusion process and sufficient care is taken with the preparation of the wood particles, the board has very even density and no considerable settling of fines to one face. Tests have shown a range of density variation across the width and across the thickness of the board at any point to be no more than approximately ± 2%. Tests with fines specially dyed to be identifiable in the finished board show very even dispersion of the fines throughout the board.

The horizontal design makes it possible to have adequate length of heated die aperture. This results in a highly cured board at the point of emission and permits high rates of output on solid boards of considerable thickness, i.e., 1½ or 2 inches. Such boards reduce the output of the multi-platen press and present versions of vertical extrusion presses.

The turbulence maintained in the particle mix, up to the moment at which it is compressed in the Lanewood press, causes a desirable orientation of the chips so that sufficient of them lie substantially in the direction of the thickness of the board to

assume great dimensional stability in that direction, yet there are a large proportion which are randomly scattered in other planes and which give good strength and stability in all directions.

Because the board from the Lanewood press is not deformed in any way as it leaves the press, it is possible to control thickness variations within 1/64-inch.

Approximate Costs of Equipment

At present prices, the equipment installed necessary to produce 800/1000 feet per hour of ¾-inch board are as follows:

Multi-platen process—$325,000–$375,000
Vertical extrusion—$180,000–$190,000
Horizontal Lanewood—$140,000–$145,000

The multi-platen process takes at least three times the building area that the extrusion processes demand.

Approximate Costs of Product

At the time of writing, the best cost figures from reliable sources show the following cost comparison between the different processes:

Based on ¾-inch board—Boards of equivalent quality
Multi-platen processes—$80.00–$95.00 per M sq. ft.
Vertical extrusion process—$75.00–85.00 per M sq. ft.
Lanewood horizontal—$50.00–$55.00 per M sq. ft.

Present Market Prices

At the time of writing, prices of regular particle board core stock ¾-inch thick range from: $140. per M ft., f.o.b. on the West Coast to $115. per M ft., f.o.b. in South-Eastern states.

Typical Test Figures on Lanewood Board

		Test By:
Compressive strength—		
1500 lbs./sq. in.		Lane Company
Screw holding:		
¾ No. 10 screw	430 lbs.	Singer Mfg. Co.
1¼ No. 9 screw (¼" upstand)	300 lbs.	Lane Company
¾ No. 7 screw	300 lbs.	
Modulus of rupture:		
Unveneered	1730 p.s.i.	Lane Company
3-ply	3740 p.s.i.	Lane Company
5-ply	4160 p.s.i.	Lane Company
Retention of swelling (After raising from 6% m.c. to 18% m.c., then redrying to 6%)	0.2%	Singer Mfg. Co.

Use of Wood Particle Board

When contemplating the use of wood particle board, there are two prerequisites: First, those in authority must be completely satisfied with their decision to use it before the material is used except experimentally; Secondly, great discipline of thinking is necessary if the user is to avoid the pitfall of hoping and believing that particle board, in addition to being a great cost saver, will answer all other difficulties and avoid all problems which are common with most other wood products.

Perhaps the best view for management to take is based on the premise that particle board is another type of lumber and, as in the case of other species, has its own peculiarities and requires its own "know how" in its application. There need be no reserve about the use of particle board made by any reliable process as being adequate for most reasonable uses. As the users of many millions of feet of multi-platen board and horizontal extrusion board, the writer and his colleagues have been convinced that the extrusion board is cheaper and better, but the multi-platen board can be used successfully.

Particle board should be offered and used on its own merits, and not as a substitute about which we feel a little guilty or self-conscious. For many purposes, it is much better than the material which it replaces.

Claims have been made that some boards can be veneered 3-ply and be used satisfactorily. This is partially true. Everything depends on the application and degree of gloss in the final finished product. Some boards, including the more expensive multi-layer type boards, are satisfactory for 3-ply use. Where such uses exist, a good extrusion board will also be satisfactory. Such applications are for:

(a) Low gloss finishes
(b) Architectural panels and vertical surfaces
(c) Plastic covered cores for kitchen furniture, school furniture, etc.

In such cases it is desirable to plane or sand the core before veneering and

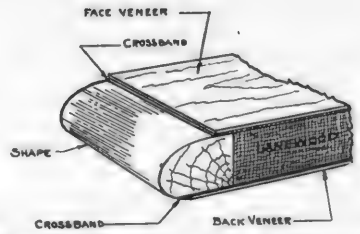

Fig. 1A.—Edges of core banded with lumber, veneers applied, edges shaped.

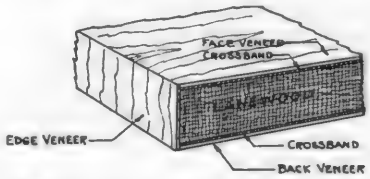

Fig. 1B.—Veneers applied to core, edges of panel banded with veneer.

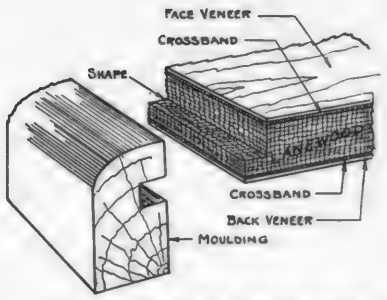

Fig. 1C.—Veneers applied to core, edges of panel shaped to fit groove in moulding.

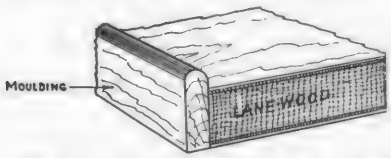

Fig. 2A.—Veneers applied to core, mouldings applied to edges of panel by high-frequency heat, clamps, etc.

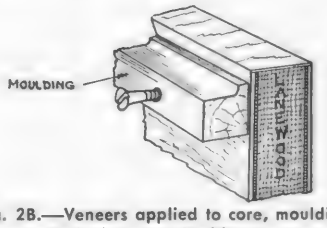

Fig. 2B.—Veneers applied to core, mouldings attached to panel with screws.

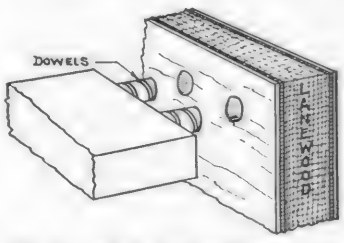

Fig. 2C.—Veneers applied to core, panel bored for dowels.

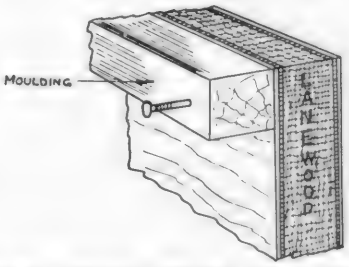

Fig. 3A.—Veneers applied to core, moulding applied to panel with nails.

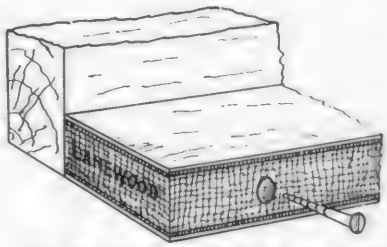

Fig. 3B.—Veneers applied to core, which is counterbored or countersunk to join to other parts with screws.

to avoid long layup times which will cause the core to take up excessive moisture. We believe it is still advisable to 5-ply the board for high gloss finishes or horizontal surfaces.

When evaluating a board for use in any situation, it is desirable to remember that it is the condition and performance of the board as used which is important. For instance, if a board is to be used in a veneered state, then, apart from the need for the board to be strong enough to get it to the veneering stage, there is no need to be concerned with the strength of the unveneered board. Make checks on the type of construction you propose to use.

It is also well to remember that many presently used materials are used because of availability, price, artistic, or other considerations. The strength and performance figures of such conventional materials can be assumed to be adequate or they would not persist. However, they may be more than adequate when considered functionally, and it is therefore only the functional suitability of the substitute material with which we are to be concerned.

In many cases it will be possible to use the board with faces and edges veneered only. This has proved a satisfactory outlet for millions of feet of board. In other cases it may be desirable to rim one or more edges of the panel with solid stock to provide edges suitable for special machining or other special applications. This can be done satisfactorily by any conventional gluing procedure, and in all cases except very small panels is likely to be cheaper than using solid stock.

Machining Particle Board

Because of the resins and the dispersal of grain direction in the particles, such boards are somewhat more abrasive than normal hardwoods. This is a matter of degree and does not of necessity call for or automatically justify the use of hard metal saws and cutters. For sawing to size or shaping edges, it may be worthwhile to use hard metal tools. For preparation of flat surfaces it is probably better not to do so. Hard metal tools will not hold the high sheer angles which are desirable for preparing surfaces for veneering or finishing.

As is well known, any surfacing tool, when minus a high shearing edge, will set up compressive loads on the surface being machined. Similar effects can be the result of too much heel on knives, or excessive feeds. With any type of material these effects are bad, but with particle board they can be disastrous. There has been much talk about "telegraphing" of defects through to the surface. It is true that much of this has been due to bad boards getting into circulation. However, much of it undoubtedly arises from careless machining.

In many cases it may be desirable to sand rather than to plane the surfaces. When solid rims are added to the board or when several pieces of waste are glued together, it is desirable to take a reasonable cut rather than to just "dust" the surfaces. When surfacing the board, it is normally important to ensure that equal cuts are taken on each side of the board.

Utilization of Scrap Particle Board

Because of its good gluing characteristics, waste pieces of particle board can be glued together at random and used for panels of suitable size. With reasonable planning of sizes in the cutting list, waste can be virtually eliminated. In the use of Lanewood from the extrusion process in more than 18 months, waste of all types has been under ½% of the press production.

Testing Standards

Simple apparatus will provide all the tests necessary to evaluate a board. These have been well described in a leaflet available from Timber Engineering Company, Washington, D. C.

In setting up standards, it is well to remember that many important criteria are purely a matter of opinion and cannot be weighed or measured. Such matters as whether a surface is smooth enough (in the wood industry at least) will remain in this category. With this in mind, it is a good idea to ensure that there is some lasting record or evaluation of the degree of trouble experienced with the material which the particle board is to replace. Unless this is done, those concerned with production and quality will progressively forget the present problems they face: sunken joints, knots showing through, etc.; and may become too hypercritical of the new material.

To avoid this situation, it may be worthwhile to make and hold as standards for educational purposes some pieces of plate glass veneered with a variety of face material with and without crossbands. When these are made it is probable that all concerned will be surprised at the amount of defects which are present and which derive from the faces and crossband veneers only. The core is often blamed whereas the fault may lay elsewhere.

Who Can Afford a Particle Board Plant

Any company or person who can obtain or has a regular supply of wood waste of 40 tons or more per week can and should afford to put in a particle board plant. At this level the plant can be paid for complete in about one year. In suitable cases, a plant may be economically justifiable at much less than this level of output.

Conclusion

There is a safe, justifiable, and desirable field for wood particle board throughout the furniture, architectural, and general wood using industries. Carefully made, properly used, and honestly offered particle board will continue to grow in volume and importance, and will remain an essential part of our forest products economy.

There is much evidence that the period of waiting is over, and many who have been hesitating are now acting to take advantage of the great savings and profits which can be made with this product.

Extruded Chipcore Board[1]

JOHN M. CRAFTON

President, Chipcraft Co., Morristown, Tenn.

Discusses manufacture of chipcore by a continuous extrusion process that may be horizontal or vertical, depending on plant facilities. Lists advantages of this process, product specifications, equipment requirements, and manufacturing costs. Description is given of complete manufacturing operation.

THE LATEST AND MOST IMPORTANT development in the utilization of wood waste and one which is gaining increasing economic stature is wood particle board or chipcore.

The first forward step toward utilizing this waste has been the development and manufacture of synthetic resins or glues at a price that makes it possible to process wood waste into a product that is economical and profitable to the manufacturer.

The second step in utilizing the wood waste of the industry has been the development of mechanical methods and machinery to process the waste into practical durable wood products. The various methods developed include moulding, pressing, rolling, and extruding of wood chip and resin mixed materials into usable board in many forms.

The product that possibly has the highest volume market at this time is one that may replace lumber core material for veneer furniture panels and plywood cores. It is called, as previously mentioned, by the generic term of "chipcore". Briefly, chipcore is made by mixing wood particles with a synthetic adhesive and then forming under heat and pressure the size board desired while the resin is being cured and integrated into the finish product.

To be most effective and economical in time, labor, and materials the process should be continuous. In the extrusion method, there is continous production of a chipcore material 90% wood substance with most of the advantages of the original wood itself and a few of the disadvantages.

As a continuous process, no one step or mechanical adaptation may be said to be more important than another. The extrusion process, like any other method, starts with mechanical processing of wood particles. With an in-plant operation, the wood waste is presumed to be around 8% moisture content. This eliminates the need for drying equipment. The first step then is the reducing of wood pieces—large and small blocks, chips, shavings, etc.—to a stream of dry, milled, and screened chips as uniform in size and shape as possible.

A heavy duty wood hog is used as the first step to insure a continuous flow of graded chip material. The wood particles resulting from the milling process go first by conveyor to screens where the fines and oversize chips are automatically removed. Oversize pieces are returned to the hog for regrinding to the uniform size desired.

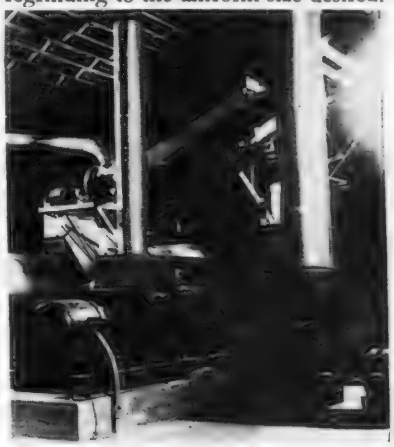

Fig. 2.—Hammer hog and screening arrangement. Chips are pneumatically conveyed from knife hog to hammer hog, then to the screen. Oversize chips return from screen to hammer hog, proper size chips go to automatic feeder for dryer. Fines are removed and pneumatically conveyed to boiler room by small fan in left center of photo.

[1] Presented at meeting of Ohio Valley Section, FPRS, May 12–13, 1955, in Louisville, Ky.

The Author: J. M. Crafton holds B. S. in industrial engineering from Virginia Polytechnic Institute, is presently engaged in sales, development, and engineering of equipment for utilizing wood wastes. He was formerly associated with The Lane Co., Altavista, Va.

Fig. 1.—Chip processing part of plant using veneer cores as major source of raw material. Knife hog is shown in immediate center; hammer hog, screen, and drying can be seen in background. The high portion of building in background is housing for vertical extruder.

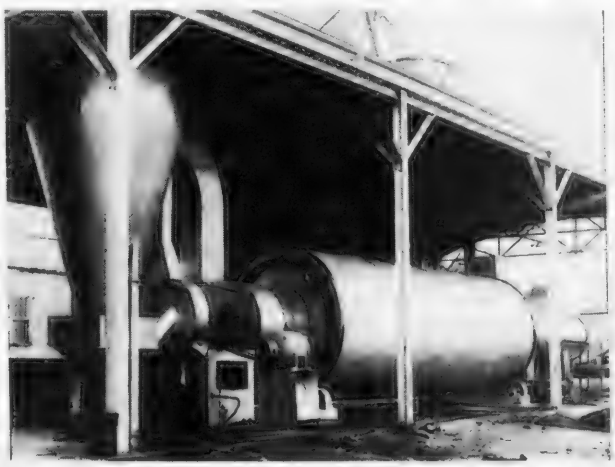

Fig. 3.—Overall view of oil-fired dryer used for drying chips to uniform moisture content. The unit is entirely automatic.

Fig. 4.—Dry chip storage silo and unloader drive and fan. The dry chips are prepared in 8-hour operation and enough chips are stored in silo for 24-hour operation of extruder. The fan pneumatically conveys chips from silo to metering unit at extruder.

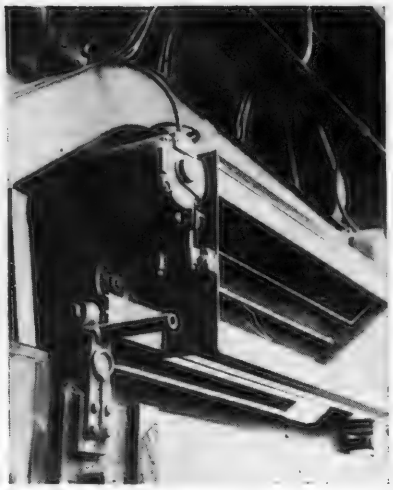

Fig. 5.—View of one side of extruder. In immediate foreground is automatic feeder for extruder. The curved chain in upper left transports the mixed chips from bin to feeder and is electrically controlled to keep a constant level of chips in the feeder.

Fig. 6.—Bottom end of extruder section. The air cylinders show the method of varying pressure on the plates, thereby varying density of the boards. The board can be seen emerging from extruding section at bottom center of photo, ready for automatic cut-off saw immediately below.

Next the wood particles pass into a storage bin, conveyed there either by screw, belt, or pneumatic system where they are accumulated prior to introduction into the chipcore manufacturing process. The handling and preparation of the wood chips up to the storage bin stage is more or less common to all resin bonded core board production and so is the mechanical equipment required. The remainder of the paper describes the principle and operation of a Chipcraft extrusion installation.

From the storage bin the chips are moved by screw and air conveyor into a cyclone above the extruding unit and thence into the material section or weighing tank. When the supply of chips reaches the proper level, the contents are automatically dumped into the mixing vat. Then the adhesive, urea formaldehyde mixed with catalyst and other ingredients, is sprayed over and onto the chips as they are mechanically agitated and thoroughly integrated with the liquid adhesive.

MANUFACTURING COSTS FOR 48-INCH VERTICAL EXTRUDER

1. **Equipment Cost** (subject change without notice)	$ 90,000.00		
2. **Material Costs**			
a. Wood Chips	$5.00 per ton		
b. Resin (62% solids)	0.095 per lb.		
c. Catalyst	0.10 per lb.		
3. **Labor**			
Machine operator	$2.00		
Machine helper	1.00		
4. **Production per Year ½" Chipcore**	3,000,000 sq. ft.		
			Cost per 1,000
5. **General Operating Expenses**			
Electricity (150 KW @ .01/KW)	$ 9,000.00		
Maintenance, Lubrication, etc.	$ 2,000.00		
		$ 11,000.00	$ 3.67
6. **Materials Cost**			
Wood chips			
3,000,000 sq. ft. @ 2 # chips/sq. ft. @ $5.00 per ton			
3,000,000 x 2 x $5.00 / 2,000	$ 15,000.00		
Resin Mix			
Based on 7½% solids			
Resin and Catalyst cost/sq. ft. is 0.025			
3,000,000 x 0.025	$ 75,000.00		
		$ 90,000.00	$30.00
7. **Labor**			
Machine operator 3 x 2.00 x 8 x 250	$ 12,000.00		
Machine helper 3 x 1.00 x 8 x 250	$ 6,000.00	$ 18,000.00	$ 6.00
8. **Overhead**			
Figure same as Direct Labor	$ 18,000.00	$ 18,000.00	$ 6.00
9. **Depreciation 10%**	$ 9,000.00	$ 9,000.00	$ 3.00
Total Mfg. Cost per Year		$146,000.00	
Mfg. Cost per 1,000 square feet			$48.67

Cost per Thousand Square Feet calculations approximate, depending on local costs.

When completely and properly mixed, the resulting resin-chip blend is uniformly metered and spread into the slot or aperture formed by steel platen plates which form the sides of the extruder mechanism. As the mix flows into the slot, a powerful ruggedly designed plunger rams and forces the chip mix down between the platens and the smooth steel sides. A dummy pre-formed plug is first used to provide resistance to the plunger when the machinery is started up. The platens are kept heated to high temperatures and are also adjustable to control thickness and size of the board to be produced. The heat is generally supplied and maintained by an electrically controlled hot oil system. Electrical heat is sometimes recommended where fluted board is produced of larger than normal thickness.

Thus by the constant power drive of the plunger, the chip-resin mix is pounded and packed into a firm cohesive material. Simultaneously and continually, the high heat in the platens is curing and setting the resin throughout the mixture. The inflow of raw material at the top is constant, the pressures within are equal, and since there is a rigid fixed orifice, the output of the finished product is also constant. The resin-chip material is forced downward between the forming sections at a rate variable between two and three feet per minute. Pressure controls the density and the steel forming sections guarantee constant dimensions.

Length, width, density, and thickness can be changed to specification requirements but once set for production, nothing is left to manual control

or adjustment. The particle board product emerges from the extrusion process as a continuous board—finished, dry, hard, and ready for glue and veneer, saw, hammer, or nail. As the board comes out at the production end of the extrusion unit, a cut-off saw takes over to cut the board off at whatever length is desired. The saw travels with the finished board and is electrically indexed to operate automatically and accurately. Lengths up to 12 feet or longer may be attained in a vertical extruder installation; with the horizontal installation lengths are theoretically limited only by the length of the building. Working lengths are generally the same whether vertical or horizontal in origin.

A wide range of densities can be accomplished by the extrusion process in that a fluted board, with holes, either the length or breadth of the board, can be made. This type product saves raw material and also reduces the density as well as the cost. By varying the pressure, the size of chips and the percentage of resin, density may be varied from .3 to .9 according to the need.

A brief listing of the various items of standard and special equipment and machinery involved in an extrusion process operating in an in-plant installation includes: 1) wood hog; 2) air conveyor installation for all movement of chip material; 3) oscillating screen for chip grading; 4) storage silo for graded prepared chips; 5) automatic metering unit for chips; 6) chip and glue mixer for integration of chip and adhesive; 7) glue mixer for preparation of glue, catalyst, and other additives; 8) feeding mechanism to provide uniform flow into extruder sections; 9) extruder unit which includes —power plunger, platens, etc.; 10) heating unit to provide and maintain heat in platens, 11) automatic cut-off saw mechanism; 12) automatic stacking unit for stacking chipcore panels for fork lift operation. Motors and

Fig. 7.—Automatic cut-off saw, tilt down conveyor, and automatic stacker. Tilt-down conveyor is in vertical position, ready to receive board from extruder.

electrical installations are included as a part of the unit items listed.

Because of the positive control of automatic production built into the Chipcraft design, one man can normally supervise and operate the extruder unit itself, including the preparation of adhesive mixtures, during an eight-hour shift. Production of board of 11/16-inch at the rate of 10,000 feet per 24 hours would thus normally require one operator per shift. Maintenance and repair are not included. The one-man operation is based on mechanical and automatic movement of wood waste and chips to and through hog to extruder. All Chipcraft installations are on an automation basis.

Major advantages inherent in the extrusion process are: 1) low labor cost; 2) wide range of densities; 3) chip orientation—chips generally lie perpendicular to board surface providing better bonding with veneer, better screw holding ability, greater strength, 4) smoother surface ready for veneer without special sanding; 5) uniform

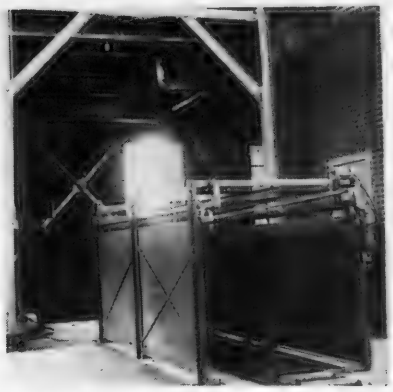

Fig. 8.—Automatic cut-off saw with tilt-down conveyor in horizontal position, ready to convey board into automatic stacker in immediate foreground.

Fig. 9.—Finished board being removed from automatic stacker by fork-lift truck.

thickness, no warpage problem; 6) firm edges, no trim needed; 7) greater flexibility as to density, width, thickness, and length of product; 8) molded and shaped products made by extrusion method; 9) low initial investment for complete operating layout; and 10) minimum space for in-plant unit, average 2500 square feet.

No two situations of wood waste utilization are alike but the same basic elements are always present. The extrusion method of manufacturing particle board demonstrates practically and profitably one way of solving the wood waste problem.

Producing Particle Board by a Continuous Process[1]

L. R. LOUIS

Vice-President, Bramco, Inc., New York, N. Y.

Describes a press designed for the continuous production of particle board, with board length limited only by means of handling. Physical properties of the board may be varied to meet end-use requirements. Plant layout needs are given and advantages of this process listed.

THE FIRST MACHINE designed for the production of high quality board by a *continuous process* is the Bartrev Press. It makes available a mass production method of providing a commercial use for the abundance of unused wood from forest, sawmill and factory which exists throughout the world.

All existing board manufacturing processes are based in their final stages on the conventional platen type of press, in which batch loading is employed, the pressing and curing being long and slow respectively and eventually producing boards of three fixed dimensions.

The conventional process of making board from wood particles and thermosetting resin, is to hold the feed between the platens of a hydraulic press of the multi-daylight type under enough pressure to secure desired compression, and at such temperature as is necessary to polymerize the thermosetting resin. This process has certain economic disadvantages. Each board must be handled as a separate unit at all stages; heating of the board must be done entirely by conduction from the heated platens of the press; and the area of the press platen dictates maximum size of board which can be made. With each board demanding individual preparation, it may be difficult to insure uniformity of physical properties throughout a batch of boards.

The Bartrev Press is designed for the continuous production of board from comminuted fibrous material bonded into a continuous sheet by thermosetting resins. The fibrous material may be from raw wood, operational wood wastes, or certain annual grasses such as bagasse, flax shives, etc.

The preparation to suitable fiber varies with the selected raw material. To meet various conditions, dictated by the condition of the selected raw material, several processes have been developed. In principal they consist of methods to: (a) reduce the raw material to uniform and correct particle size, and (b) control the moisture content to a predetermined and uniform level.

A flow diagram showing typical equipment requirements for a plant using pulpwood, cull logs, etc., as the raw material is shown in Fig. 1. Variations from this will be made to suit the condition and shape of other suitable raw materials.

Description of Press Units

The continuous press consists of the following integrated and synchronized units:

1. A continuous flow type resin mixer where the thermosetting resin, or other additives affecting the properties of the board, is added in liquid form and sprayed at the desired rate into the mass of prepared feed which is violently agitated.

2. A continuous feeder unit provides a means of laying an even carpet of the resinated prepared feed on a stainless steel belt to suit the thickness and density of the board to be produced. This feeder unit at option may be adjusted to supply a homogeneous carpet or a layer construction for surface effects on the resulting board. Included in the unit is a compactor for prepressing, after laying the carpet of resinated material.

3. A high-frequency heater provides means of heating this carpet throughout to a suitable temperature before entering the pressure unit of the press. The temperature attained here is 70° to 75° C.

4. A pressure unit compresses the carpet and raises it to a sufficient temperature to cure the resin, while under pressure, and holds the compressed carpet at the required thickness.

The final heating stage has to be effected in the press by transfer through platens heated to 140°–145° C. according to the type of board to be produced. This temperature is maintained by thermostatic control until the compressed carpet leaves the pressure unit as fully cured, fully compressed board.

The stainless steel bands are carried on steel pulleys, four to each band. Tension is applied to the bands and automatic adjustment to the pulleys is provided to insure true parallel movement. Provision is also made to insure that contraction of the bands on cooling does not introduce any risk of overstressing either the bands, pulleys and supporting structure. The entire press is driven by an electric motor operating through a gear box permitting speeds between 5 and 32 feet per minute. Devices for carrying rolls of paper and other surfacings and applying these are incorporated in the press.

5. An automatic sawing unit provides a means of trimming and cutting the board as it emerges from the pressure unit. The transverse saw can be adjusted to cut to any length limited only by the means of handling.

Building Requirements

The press is compact in layout and, considering its production capacity, relatively small in size, thus developing favorable economies in building requirements. The dimensions are:

Overall length	155 ft.	Approx.
Width	8 ft.	Approx.
Height	20 ft.	Approx.
Weight	200 tons	Approx.

Depending on the type of run off tables and off loaders used, the plant designer may have to allow space up to 190 ft. in length for the complete press function.

The annual production will vary from 13,000 to 31,000 tons, or from 20 to 53 million sq. ft. depending on density and thickness of the board produced, and the work year.

The continuous press reaps all the economies and advantages that derive from continuous and automatic production. These are many and varied and appear with greatest contrast in

[1] Presented at FPRS North-Central Region Meeting, Nov. 15–17, 1955, in Chicago, Ill.

an evaluation of board properties when related to sales appeal and the cost statement for board production. Additional advantages are inherent in this press by reason of design. Some of these may be generalized as follows:

(a) This press is a versatile board production tool. It will, at option, produce boards with a density range from 0.50 to 0.80. By varying the density and resin content, it is possible to tailor the board product to end use requirements. Most of the adjustments needed to vary the board properties can be accomplished without a long shutdown. A complete change in thickness, density, and resin content can be made with a downtime period of 8 to 11 minutes. This downtime does not necessarily affect the continuous production of the raw feed since surge capacity is normally provided.

(b) It produces board with only one fixed dimension—4 ft. width. Thickness can be varied from 1/4 to 3/4 inch. The length can be from 4 feet to any length limited only by means of handling. This permits sales of board without cut-off waste, which is of substantial economic benefit to the user. The edge trimming and transverse cut, to selected length, is wholly automatic.

(c) Through design, this press permits the simultaneous application of surfacings to the board during production and without recourse to a secondary operation. These surfacing ma-

Fig. 2.—Side view of continuous press for manufacturing particle board.

Fig. 3.—Automatic sawing unit trims and cuts board emerging from the pressure unit.

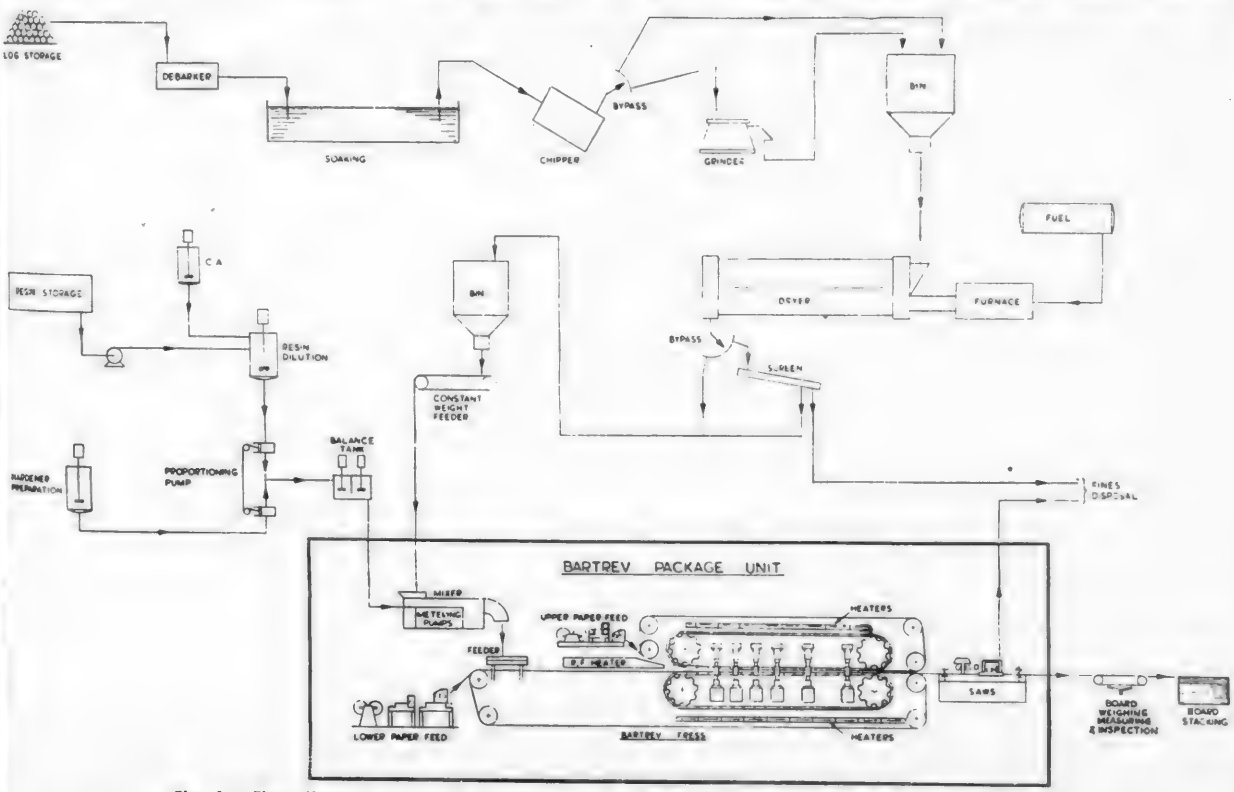

Fig. 1.—Flow diagram showing equipment needs for plant using pulpwood cull logs as raw material.

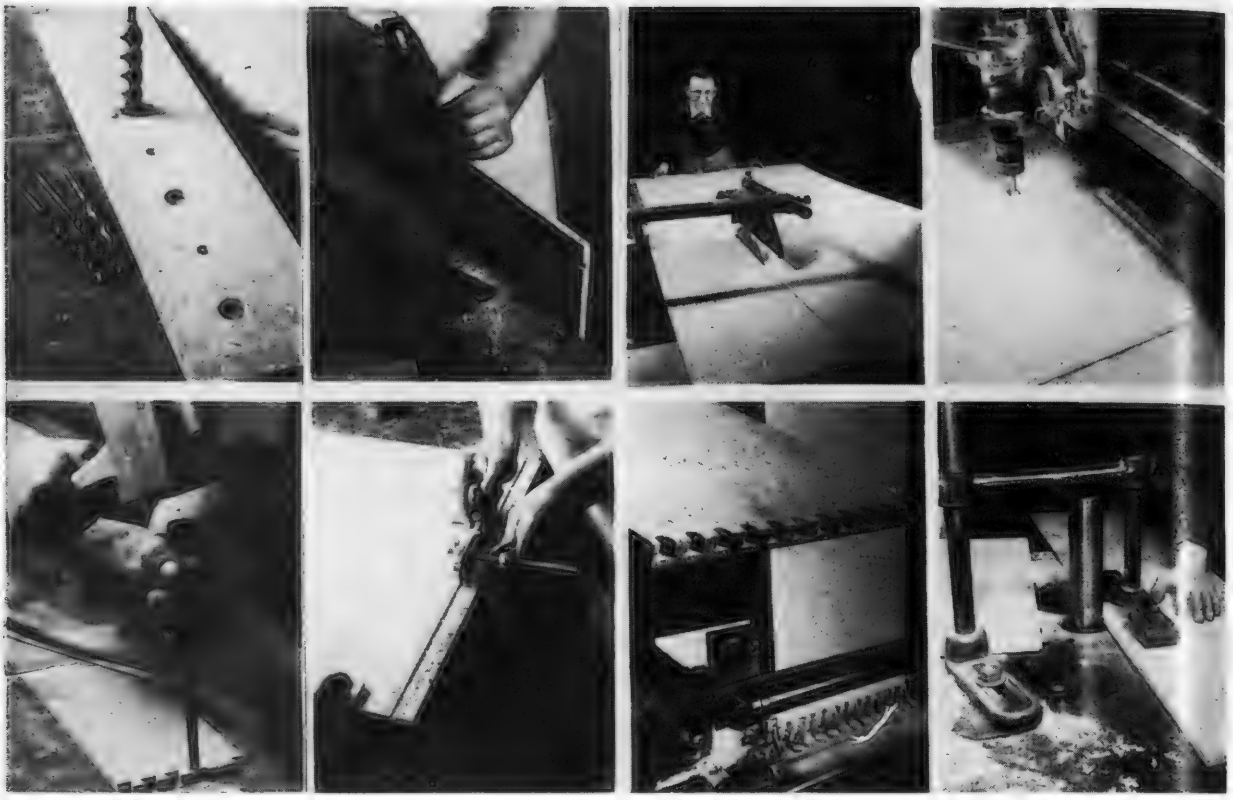

Fig. 4.—Machining particle board. Top, left to right: boring, planing, sawing, routing; bottom: dovetailing, routing, dovetailing, shaping.

terials may be paper, plain or decorated; metal foils; water-proof papers; plastics, etc. The only limitation on such surfacings is their availability in large roll form, approximately 50 inches wide, and their ability to be inert under the temperature conditions met in the press.

(d) The press has little if any throughput loss of the prepared and resinated feed. The transverse cut is the width of the saw kerf; the edge trim can be as small as ½ inch. The board thickness is held to a tolerance closer than a planing operation, and in consequence there is no feed loss due to sanding required to attain commercial thickness tolerances.

(e) Being a continuous and wholly automatic machine this press eliminates most of the human elements in manufacture and the variation necessarily inherent to a batch process. Quality controls are therefore more easily established and the result is a board product of high uniform quality. Mentioned previously was the close control on thickness. The carpet laying device, working on both bulk and weight factors, controls the density to within 5%. Board produced on this press, when used as core material for veneers, plastic laminates, etc., does not require cross banding or customer sanding.

Physical Properties

The physical properties of board produced on this continuous press will, of course, vary according to the quality and characteristics of the raw material, resin content, and density. With a 7% resin (urea formaldehyde) content, the physical properties in the table below should be exceeded by a variable margin.

These properties place such boards in a wide range of use in the construction and furniture industries—or wherever boards in the medium densities are presently employed. The dimension of this market can be visualized as the aggregate use of plywood (interior grade) and solid edge glued core material, as well as many applications now proprietary to hardboard. That this market is a wide and expanding one is fully attested to by historical statistics and all responsible projections on future use.

Properties	Material					
	Planer Mill Shavings			Prepared Shavings		
	Softwood			Softwood		
Density	0.65	0.70	0.75	0.65	0.70	0.75
Modulus of Rupture, p.s.i. (Flexural strength)	2500	3000	3500	4000	4500	5000
Compression Strength, p.s.i.	2500	2500	2500	2800	2800	2800
Tensile strength, p.s.i.	1900	2300	2600	3000	3100	3300

Relationship of Moisture Content and Flexural Properties in 25 Commercial Hardboards [1]

J. R. STILLINGER and W. G. COGGAN

The continued increase in production of hardboard has created a need for more information on the relationship of moisture and flexural properties in the broad range of commercial hardboard. Such information can assist the hardboard industry in setting up sound standards and specifications for evaluating hardboard properties.

THIS STUDY WAS PART of a comprehensive research program undertaken at the Oregon Forest Products Laboratory to aid the hardboard industry in evaluating the physical properties of commercial hardboard.

Review of literature: There is little information in the literature on the relationship between moisture content and flexural properties in commercial hardboards. Several reports have been written on evaluation of the physical properties of hardboard and several mention the fact that moisture content apparently does affect the flexural properties.

The U. S. Forest Products Laboratory (2, 4)[3] while working with other physical properties of hardboard recognized the importance of considering moisture content in evaluating these properties; however, few data are available which specifically show the relationship of moisture content to flexural properties.

Although it was not the primary objective to investigate the effect of moisture content on strength, Farber (3) found there was an increase in toughness accompanied by a loss in bending strength when the moisture content of hardboard was increased. Farber's hardboard was a special experimental board made from hardwood fibers and the information was not sufficient to show that the same behavior could be expected in commercial hardboards.

The average equilibrium moisture content of hardboard and wood at three different humidities has been reported (2) as follows:

Relative humidity	Average equilibrium moisture content	
	Hardboard	Wood
Per cent	Per cent	Per cent
33	4.5	7.0
65	8.0	13.0
90	12.5	20.0

The moisture content for the hardboard was obtained by first drying the boards, then exposing them to the different humidities.

Objective: The major objective was to measure the effect of moisture content on modulus of rupture, modulus of elasticity, work to maximum load, and work to 0.2-inch deflection for 25 types of commercial hardboard.

Work to 0.2-inch deflection was chosen instead of work to the proportional-limit load because the proportional-limit load in hardboard is not well defined and it was desired to observe the effect of varying moisture content on work values within the proportional-limit range.

It was not within the scope of this project to evaluate the different processes and raw materials, but only to determine the relationship of moisture content and flexural properties in several types of commercial hardboard.

Experimental Procedure

Collection of test material: Twenty-five types of commercial hardboard were selected from 10 manufacturers' products. For the purposes of this discussion, "type" refers to one company's hardboard of a given thickness and classed as "treated" or "untreated". In choosing the manufacturers, an attempt was made to represent a broad scope of processes, raw materials, and treatments in order to get a representative cross section of the products produced by the hardboard industry.

The different manufacturers were asked to select at random five 4- by 8-foot sheets for each type of hardboard that they produced in the 1/8-inch and 1/4-inch thicknesses. The 4- by 8-foot sheets were sent to the Oregon Forest Products Laboratory, Corvallis, and cut into test specimens. It was not known with certainty whether the boards were representative since it was each manufacturer's responsibility to select a representative sample. A description of the 25 types of hardboard used in the experiment is outlined in Table 1.

Table 1.—DESCRIPTION OF THE 25 TYPES OF COMMERCIAL HARDBOARD USED IN THE STUDY OF THE EFFECT OF CONDITIONING ON FLEXURAL PROPERTIES

Type	Company	Process	Thickness Inches	Class	
				Treated	Untreated
1	1	Wet	1/8	---	x
2	1		1/4	---	x
3	2	Wet	1/8	---	x
4	2		1/4	---	x
5	3	Wet	1/8	---	x
6	3		1/4	---	x
7	3		1/8	x	---
8	3		1/4	x	---
9	4	Wet	1/8	---	x
10	4		1/4	---	x
11	4		1/8	x	---
12	4		1/4	x	---
13	4		1/4*	---	x
14	5	Semi-dry	1/8	---	x
15	5		1/4	---	x
16	6	Dry	1/8	---	x
17	6		1/8	x	---
18	6		1/4	---	x
19	7	Semi-dry	1/8	---	x
20	7		1/4	---	x
21	8	Dry	1/4†	---	x
22	8		1/4†	---	x
23	9	Dry	1/8	---	x
24	10	Wet	1/8	---	x
25	10		1/8	x	---

*Low-density 1/4-inch untreated board from Company 4 to avoid confusion with the regular 1/4-inch untreated board.

†The two types from Company 8 differed in resin content only.

[1] A contributed paper from Oregon Forest Products Laboratory, State Board of Forestry and School of Forestry, Oregon State College, Cooperating, Corvallis, Ore.

[2] Numbers in parentheses refer to literature cited.

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W. G. Coggan received B. S. from Purdue U., M. S. from Oregon State College. He worked toward his thesis at the Oregon Forest Products Laboratory, is now on duty with the U. S. Army.

Table 2.—ANALYSIS OF VARIANCE FOR MODULUS OF RUPTURE OF 1/8 INCH UNTREATED BOARD FROM COMPANY A

Variation due to	Sum of squares	Degrees of freedom	Mean square	F	Remarks
Boards	9,545,799	4	2,386,450	4.66	Significant*
Conditioning	14,522,216	5	2,904,443	5.68	Significant
Direction	1,642,753	1	1,642,753	3.21	Not Significant
Conditioning X Direction	1,006,000	5	201,200	0.34	Not Significant
Error	24,064,941	44	546,930		
Total	50,781,709	59			
Pooled Error	25,070,941	49	511,652		

*Significant at the 5 per cent significance level.

Cutting test specimens: The experimental work was planned so the results of the physical testing could be analyzed by statistical methods. A randomized block design was used. Each of the 25 types of hardboard was assigned a number from 1 to 25; the five boards for each type had the same code number. Each 4- by 8-foot sheet was marked into 36 8-inch squares; 12 of these squares were selected with the aid of a table of random numbers and a 3- by 8-inch bending specimen was cut from each. Six of the bending specimens were cut with the length parallel to the machine direction of the sheet and labelled "V"; six were cut with the length perpendicular and labelled "H." The machine direction of a sheet of hardboard refers to the orientation of the board with respect to its line of flow in the pressing operation during manufacture. Because of the different processes, some types of hardboard exhibit directional properties; therefore, this variable was included in the experimental design. Two bending specimens, one "H" and one "V" from each of the five boards in each type, were assigned to six conditioning treatments by the use of a table of random numbers. This cutting plan yielded 60 bending specimens for each type of board, or a total of 1500 specimens for bending. Thirty of these specimens were sawed in the vertical direction and 30 were sawed in the horizontal direction for each board type.

After the specimens were cut, they were stored in a room maintained at 70° F. and 65 per cent relative humidity for a sufficient length of time to reach an equilibrium moisture condition before the conditioning treatments were started.

Conditioning procedure: In order to observe the effect of moisture content on the flexural properties of the various hardboards, it was necessary to condition the test specimens to various moisture content equilibria. A small experimental dry kiln was used for this purpose because of the ease with which humidity could be controlled.

A convenient method for conditioning test specimens to various controlled moisture equilibrium levels would have been to oven-dry all the specimens first and then place them in constant-humidity atmospheres until they reached equilibrium moisture contents; however, the results of a preliminary experiment indicated that oven-drying significantly affected the modulus of rupture of the test specimens. Therefore, it was decided that the specimens should be placed in the kiln to remain until they reached equilibrium at each relative humidity level.

A constant dry-bulb temperature of 120° F. was used for all the relative humidities because it was the lowest dry-bulb temperature that could be controlled in the kiln over the wide range of relative humidities used. A low dry-bulb temperature was used to minimize or possibly eliminate the effect temperature might have on the flexural properties of the boards. Five different relative humidities ranging from 10 to 90 per cent were chosen to give a wide range in equilibrium moisture contents. Frequent weighings were taken on one specimen from each type of board in the kiln to determine when the specimens had reached equilibrium. When all the specimens in the kiln had reached a constant weight, they were removed for testing.

Ten specimens for each type of board were assigned to the oven-dry humidity level and were dried in an oven at 212° F. As soon as a constant weight was reached, they were removed for testing.

Testing procedure: A Tate-Emery Air Cell of 200-pound maximum capacity was attached to the movable cross-head of a 20,000-pound Tinius-Olsen electro-mechanical universal testing machine to measure the bending loads. A headspeed of 0.5 inch per minute and a span of six inches were used. The load was read on the air-cell load indicator to the nearest one-half pound.

When the specimens reached equilibrium at a particular humidity level, a group of 10 specimens representing one type was removed from either the kiln or the oven. The specimens were allowed to cool for five minutes and then weighed to the nearest 0.1 gram and measured to the nearest 0.001 inch in thickness. The specimens were not measured for width because they were cut 3.00±0.01 inches wide. After the specimens were weighed and measured, they were subjected to the static bending test using center-point loading. A load-deflection curve was plotted for each test specimen. After the specimens were broken (except for those tested in the oven-dry condition) they were put into the drying oven and dried to a constant weight for moisture-content calculations.

From the results of these tests, moisture content (based on oven-dry weight), modulus of rupture, modulus of elasticity, work to maximum load, and work to a 0.2-inch deflection were calculated for each specimen using standard methods.

Statistical Analysis

Previous experience at the Oregon Forest Products Laboratory indicated that the type of process used in the manufacture of hardboard influences the physical properties of the boards; for this reason, a factorial analysis of variance was made for each of the 25 types of hardboard. The experiment was designed so that the test data could be analyzed as a 2 by 6 factorial experiment in randomized blocks, with each of the five boards within a type representing a block. The two main effects were relative humidity level designated as conditioning treatment and machine direction. The level of significance used was 5 per cent.

Details of the analysis of variance can be found by consulting any standard statistics text. One example of an analysis of variance is illustrated in Table 2.

The interaction of conditioning treatment by machine direction tests whether the conditioning treatment had a differential effect on the various properties of the boards for each machine direction. For example: if the average values for modulus of rupture in each direction were plotted for the five specimens of a given type of board, the result would be two curves if the board exhibited directional properties. If no interaction existed, the curves would be parallel with each other and differ only in magnitude. Any appreciable deviation from parallelism would indicate the possibility of a significant interaction. If the two curves did deviate, then conditioning did not affect the specimens in the same manner for each direction. For this reason, when significant interactions occur, it is not possible to make a specific statement concerning the effect of con-

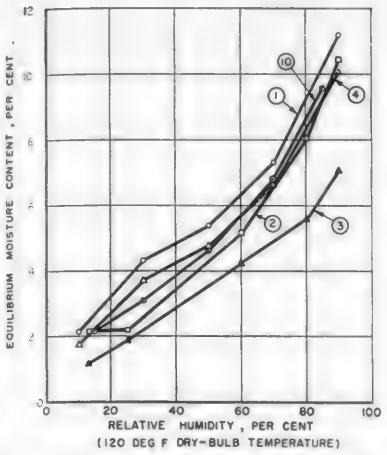

Fig. 1.—Equilibrium moisture contents of several ⅛-inch untreated, wet-process hardboards conditioned at 120° F. and various relative humidities.

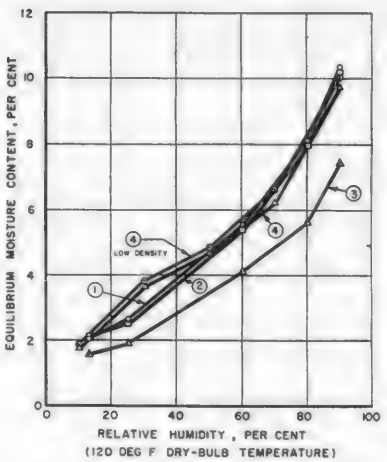

Fig. 2.—Equilibrium moisture contents of several ¼-inch untreated, wet-process hardboards conditioned at 120° F. and various relative humidities.

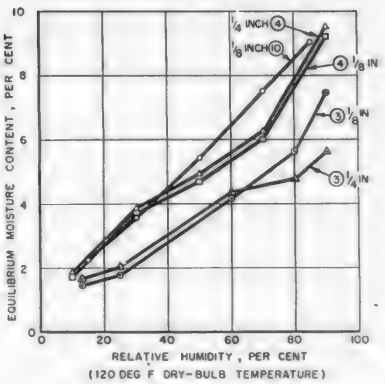

Fig. 3.—Equilibrium moisture contents of several treated, wet-process hardboards conditioned at 120° F. and various relative humidities.

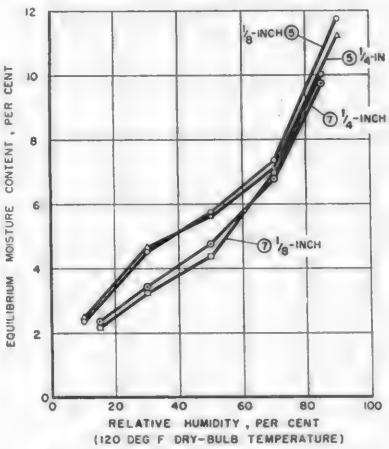

Fig. 4.—Equilibrium moisture contents of several untreated, semi-dry process hardboards conditioned at 120° F. and various relative humidities.

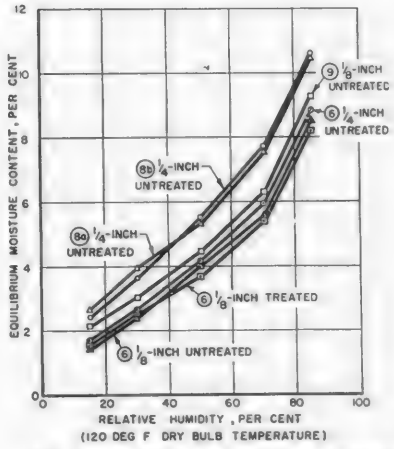

Fig. 5.—Equilibrium moisture contents of several dry-process hardboards conditioned at 120° F. and various relative humidities.

ditioning on the various properties of the boards without also considering the machine direction.

It should be pointed out that because the level of significance used was 5 per cent, interactions could be expected to be declared significant 5 per cent of the time because of chance variation.

Results and Discussion

The possible comparisons that could be made in Figures 1 through 25 are numerous. Rather than attempt to point out the comparisons that may be most important, the authors have made a few general statements for each of the properties studied and leave to the reader detailed comparisons among different processes, thicknesses, and classes of board.

Equilibrium moisture contents: Since different types of hardboard did not reach the same equilibrium moisture content for any given level of relative humidity, relative humidity rather than moisture content was used to evaluate the effect of changes in moisture absorption and desorption on the flexural properties of the hardboards. In other words, it was considered wise to compare properties for the different types of boards after exposure to similar conditions of temperature, relative humidity, and time rather than at constant moisture content levels which could result from different exposure conditions.

Figures 1, 2, 3, 4, and 5 show the average equilibrium moisture contents for each type of board at the various relative humidity levels used in the conditioning procedure. It is recognized that an absolute equilibrium moisture content was not reached; however, the specimens probably were quite close to equilibrium since period weighings indicated no change in weight after 45 hours' exposure to given temperature, humidity, and air-velocity conditions. Approximately 45 hours were required for all the specimens in the kiln to reach a moisture equilibrium in an atmosphere of 120° F. at several relative humidity levels with an air velocity of approximately 600 feet per minute. Periodic weighings indicated that at any given relative humidity, the ⅛-inch untreated boards reached equilibrium before the ¼-inch untreated boards and that the treated boards in both thicknesses were the last to reach equilibrium. Although some types of board reached equilibrium before others, all test specimens were left in the kiln until the last group (type) reached equilibrium. This action was taken to maintain the length of the conditioning period constant and thus eliminate variation in flexural properties of the boards because of a possible time-temperature effect. This possibility was not thought likely, but no information on this relationship was available for hardboard.

Not much emphasis should be placed on small deviations from the general shape of the curves because of the difficulty of controlling relative humidity within narrow limits. Small differences in temperature can mean sizable differences in relative humidity. For example: at 120° F. dry-bulb temperature, a difference in wet-bulb depression of 2° F. will produce a change of 3 per cent in relative humidity. Even at the lower relative humidity levels, a wet-bulb depression of 25 compared with 26° F. will change the relative humidity 2 per cent.

Another plausible explanation for lack of smoothness in the curves is possible error in moisture content. The presence of additives in hardboard may produce a difference between the apparent and actual moisture content.

All the curves exhibited the same general curvilinear shape regardless of process, thickness, or treatment. In all tests the boards from company 3 reached lower moisture contents than did comparable boards from other companies at any given relative humidity. Apparently this company is able to change more effectively the hygro-

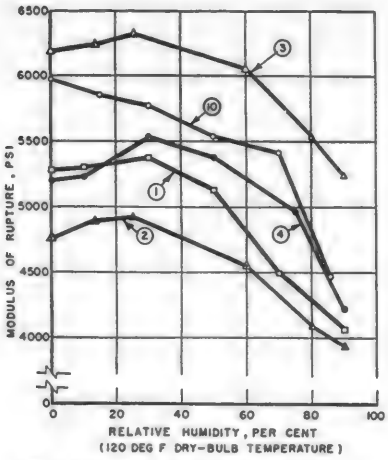

Fig. 6.—Effect of relative humidity conditioning at 120° F. on modulus of rupture for several ⅛-inch, untreated, wet-process hardboards.

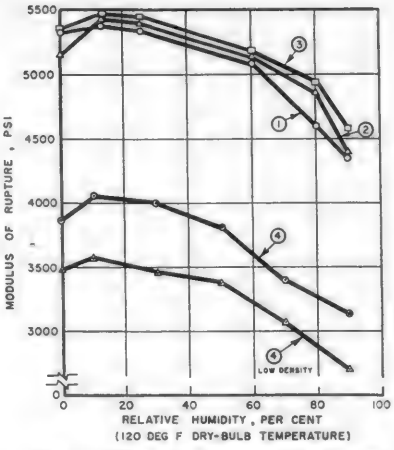

Fig. 7.—Effect of relative humidity conditioning at 120° F. on modulus of rupture for several ¼-inch, untreated, wet-process hardboards.

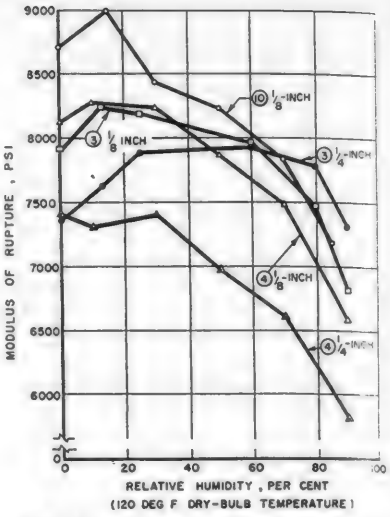

Fig. 8.—Effect of relative humidity conditioning at 120° F. on modulus of rupture for several treated, wet-process hardboards.

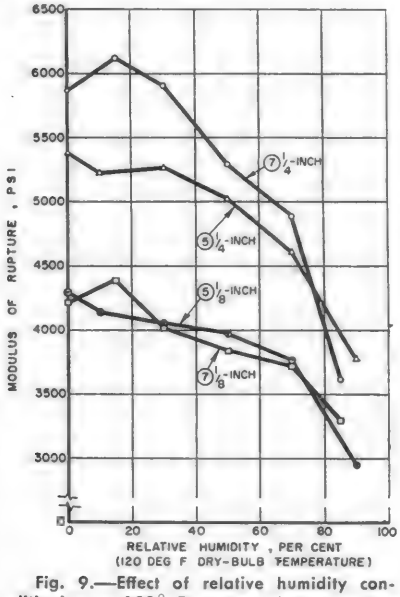

Fig. 9.—Effect of relative humidity conditioning at 120° F. on modulus of rupture for several untreated, semi-dry process hardboards.

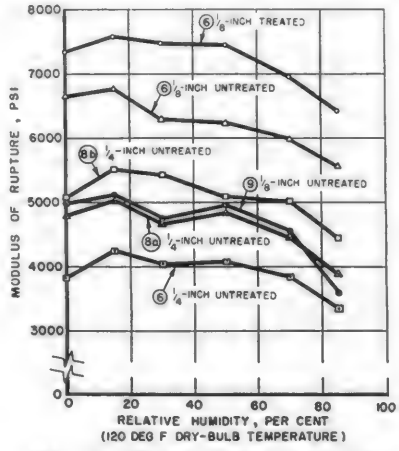

Fig. 10.—Effect of relative humidity conditioning at 120° F. on modulus of rupture for several dry-process hardboards.

scopic properties of the wood fiber than are the other hardboard companies.

Figure 4 is an illustration of boards with different thicknesses from the same process and company reaching moisture contents of nearly equal magnitude at each relative humidity level.

The dry-process hardboard (Fig. 5) exhibited the most uniform relationship of moisture content and relative humidity among companies of any of the hardboard types studied.

The hygroscopicity of the wood fibers used in the manufacure of hardboard is significantly affected during the manufacturing process. The equilibrium moisture content for wood at 120° F. and 90 per cent relative humidity is about 20 per cent, but none of the hardboard types reached moisture contents over 12 percent. Previous work (2) indicates that the equilibrium moisture content of one hardboard was approximately 60 per cent that of wood for the same conditions of temperature and humidity.

Effect of conditioning: *Modulus of rupture.* The statistical analysis for modulus of rupture showed that conditioning significantly affected the modulus of rupture for all types of boards studied except the ¼-inch wet-process treated board from Company 3 and the ¼-inch dry-process untreated board from Company 6.

For all types of boards studied (Figs. 6, 7, 8, 9, and 10), regardless of process, treatment, or thickness, modulus of rupture was lowest when the boards were conditioned at the highest relative humidity. As relative humidity was decreased, the modulus of rupture increased, reaching a maximum in the range of 10 to 30 per cent relative humidity for most types of boards. From the 10 to 30 per cent level to the oven-dry condition, most boards decreased or remained unchanged in modulus of rupture; however, 5 of the 25 types showed a slight increase in bending strength.

It has long been known that wood increases in bending strength as its moisture content is decreased and reaches a maximum bending strength when it is oven-dry. Hardboard does not behave in this manner. Although the specimens increased in bending strength with decreases in moisture content, in most instances they reached a maximum bending strength before they were completely dry. At the present time, there is no tenable explanation for this phenomenon but probably it can be found by a study of the rheological properties of hardboard.

Modulus of elasticity. The statistical analysis for modulus of elasticity showed that conditioning the boards to equilibrium at various relative humidities significantly affected the modulus of elasticity for all types of boards studied.

The effect of conditioning on modulus of elasticity is very similar to the effect of conditioning on modulus of rupture and the same general observations apply. This behavior is illustrated in Figs. 11, 12, 13, 14, and 15. The asymmetrical shape of curves for several companies' products indicates that process variables influence the flexural behavior of the boards.

The dry-process untreated hardboards as a group were stiffer than either the wet or semi-dry process untreated boards. In some instances they were comparable to treated wet-process boards.

When wood is dried below the fiber saturation point, the cell walls shrink and become more dense with the fibers becoming stiffer; thus, a decrease in moisture content is accompanied by an increase in stiffness. Wood reaches

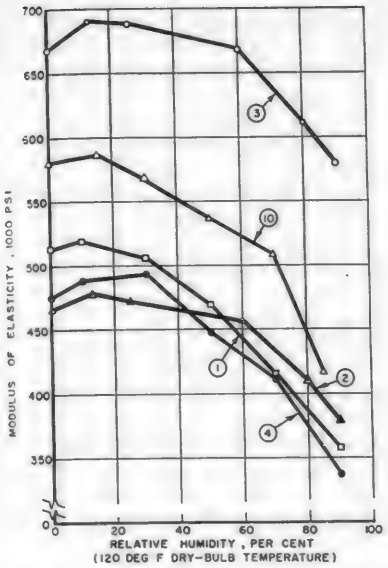

Fig. 11.—Effect of relative humidity conditioning at 120° F. on modulus of elasticity for several ⅛-inch, untreated, wet-process hardboards.

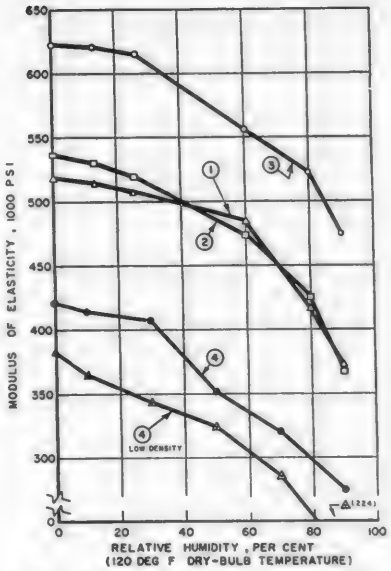

Fig. 12.—Effect of relative humidity conditioning at 120° F. on modulus of elasticity for several ¼-inch, untreated, wet-process hardboards.

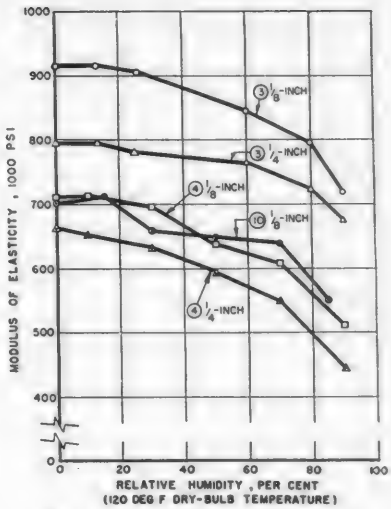

Fig. 13.—Effect of relative humidity conditioning at 120° F. on modulus of elasticity for several treated, wet-process hardboards.

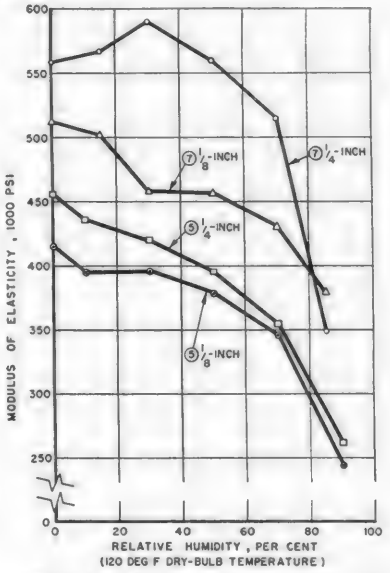

Fig. 14.—Effect of relative humidity conditioning at 120° F. on modulus of elasticity for several untreated, semi-dry process hardboards.

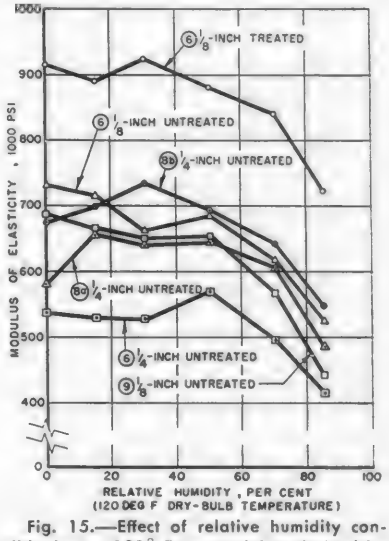

Fig. 15.—Effect of relative humidity conditioning at 120° F. on modulus of elasticity for several dry-process hardboards.

a maximum stiffness in the oven-dry state. The same general performance is characteristic of hardboard, except that in some types exposure to relative humidities below 30 per cent caused either a slight to marked decrease or no change in stiffness. The extent to which the physical and chemical properties of the wood fiber have been altered by the manufacturing process may account for the differences in stiffness behavior between normal wood fibers and those that constitute hardboard.

Work to maximum load. The statistical analysis for work to maximum load showed that conditioning significantly affected work to maximum load in 17 of the 25 types of hardboard studied.

The general trend of the curves for work to maximum load (Fig. 16, 17, 18, 19, and 20) indicates that work to maximum load was lowest when the boards were conditioned at the oven-dry moisture condition and increased to a maximum when the boards were conditioned at the highest relative humidities; however, there were exceptions to this trend.

Generally, wood decreases slightly in work to maximum load as moisture content increases; however, there are notable exceptions in some species. The difference in behavior between maximum work values for wood and hardboard with respect to changes in moisture content probably can be explained by the increasing brittleness in hardboard attended by decreasing moisture content. The comparatively high temperature used in manufacturing hardboard is probably the main factor contributing towards embrittlement.

The semi-dry and dry process hardboards as a group were less affected by changes in moisture content than were the wet-process boards. This difference was most pronounced in the dry process boards.

The work to maximum load values for the treated, wet-process hardboards were affected by changes in relative humidity in approximately the same manner as were corresponding untreated, wet-process boards.

Work to 0.2-inch deflection. The statistical analysis for work to 0.2-inch deflection showed that conditioning the hardboard at various relative humidity levels significantly affected work to 0.2-inch deflection for all types of boards studied except the ⅛-inch untreated board from Company 6.

A deflection of 0.2-inch was chosen since it was desired to observe the effect of conditioning on a work value within the proportional-limit range. The deflection at the proportional-limit load was not chosen because it was not clearly discernible for many boards; therefore, a 0.2-inch deflection was chosen arbitrarily because it remained within the straight-line portion of all curves for every type of board studied.

Generally, work to 0.2-inch deflection increased as the relative humidity decreased. All the boards had their lowest values for work to 0.2-inch deflection at the highest relative humidities but reached their highest values at different relative humidities.

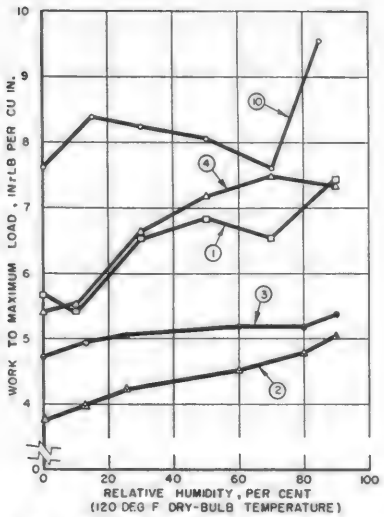

Fig. 16.—Effect of relative humidity conditioning at 120° F. on work to maximum load for several 1/8-inch, untreated, wet-process hardboards.

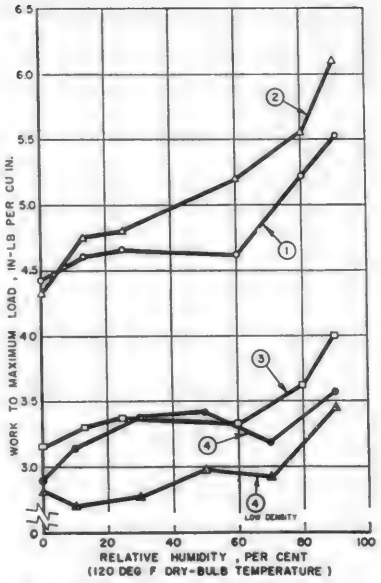

Fig. 17.—Effect of relative humidity conditioning at 120° F. on work to maximum load for several 1/4-inch, untreated, wet-process hardboards.

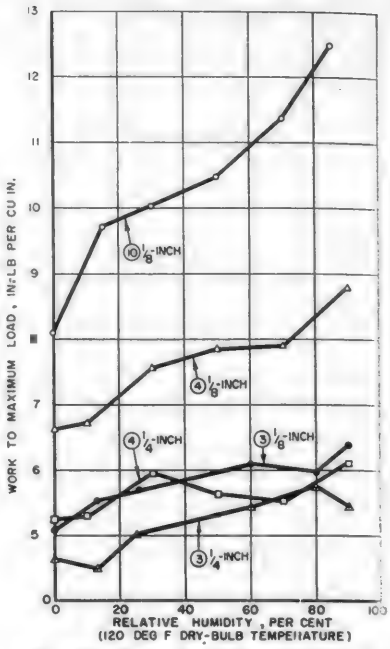

Fig. 18.—Effect of relative humidity conditioning at 120° F. on work to maximum load for several treated, wet-process hardboards.

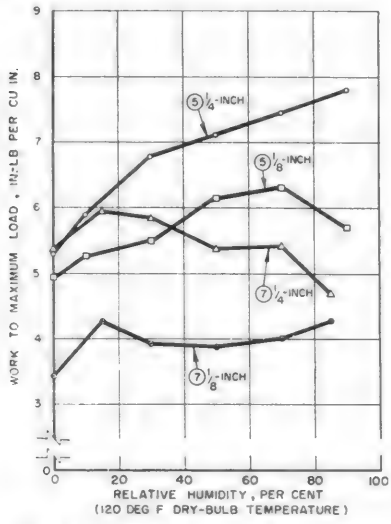

Fig. 19.—Effect of relative humidity conditioning at 120° F. on work to maximum load for several untreated, semi-dry process hardboards.

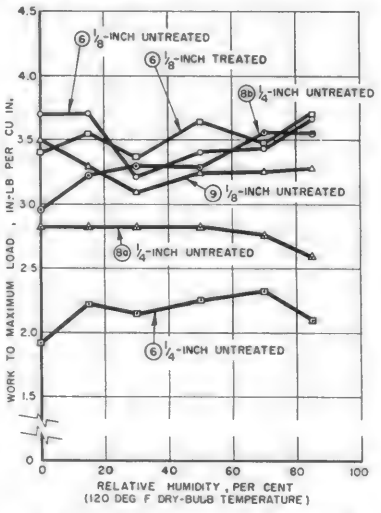

Fig. 20.—Effect of relative humidity conditioning at 120° F. on work to maximum load for several dry-process hardboards.

Although work to maximum load increased as the relative humidity increased, work to 0.2-inch deflection increased as the relative humidity decreased. Work to 0.2-inch deflection was taken within the straight-line portion of the load-deflection curve and therefore is related directly to the modulus of elasticity; consequently, the curves for work to 0.2-inch deflection are nearly identical in shape to the modulus of elasticity curves.

It should be pointed out in comparing the figures illustrating work to 0.2-inch deflection that the ordinate scales vary greatly, making it difficult to make comparisons among different processes, treatments, and thicknesses.

The 1/8-inch untreated boards exhibited much less change per unit relative humidity than did the comparable 1/4-inch untreated boards, and smaller differences among companies were observed in the 1/8-inch material.

Marked differences among companies was apparent for boards of the same thickness and class.

Variation in flexural properties among board types: Selection of test specimens for this project involved sampling five boards for each type of hardboard studied. A randomized block experimental design was used since it was desired to determine if significant differences existed in the flexural properties among boards of the same type when they were conditioned at various relative humidities. The statistical analyses indicated that significant differences were found among boards within a type for most types of boards investigated. Since the method of sampling used at each company was not known with certainty, it is quite possible that, in those cases where a significant difference among boards within a type was not detected, the method of sampling may not have been carried out as instructed. Certainly there is considerable evidence that in a representative sample of boards from a given type, significant difference in properties among boards can be expected.

The differences among boards of the same type probably was caused by differences in specific gravity among the boards.

This significant difference among boards suggests the wisdom of sampling more boards with less emphasis on number of test specimens within a given board if a reliable, representative, property evaluation is desired for a given type of hardboard.

Variation because of machine direction: Because of differences in the various hardboard manufacturing processes, some types of boards exhibit directional properties. Directional properties are caused by the fibers being aligned to a greater or lesser degree parallel or perpendicular to the machine direction during the felting or forming step in the manufacturing process. Directional properties were observed for some types of hardboard; however, findings were quite variable. Significant differences were found in some flexural properties and not in others for the same type of board. Furthermore, in comparing two types of boards from a single manufacturer, one type did and one did not exhibit directional properties.

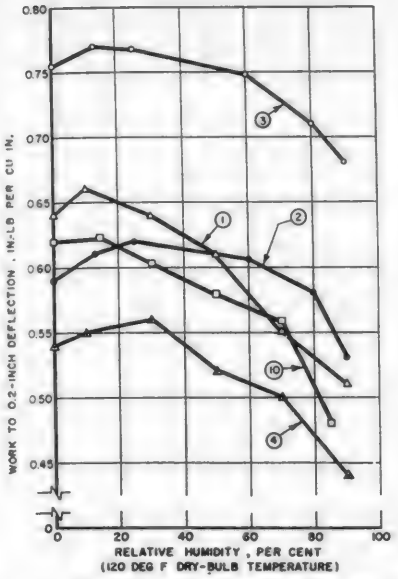

Fig. 21.—Effect of relative humidity conditioning at 120° F. on work to 0.2-inch deflection for several ⅛-inch, untreated, wet-process hardboards.

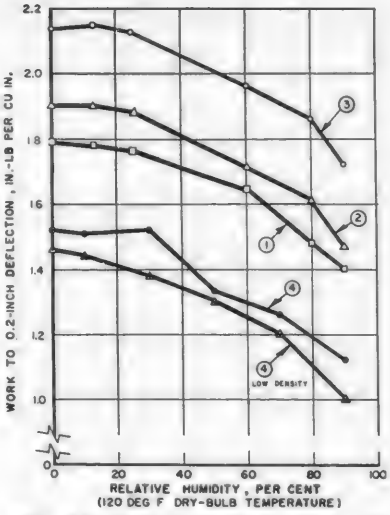

Fig. 22.—Effect of relative humidity conditioning at 120° F. on work to 0.2-inch deflection for several ¼-inch, untreated, wet-process hardboards.

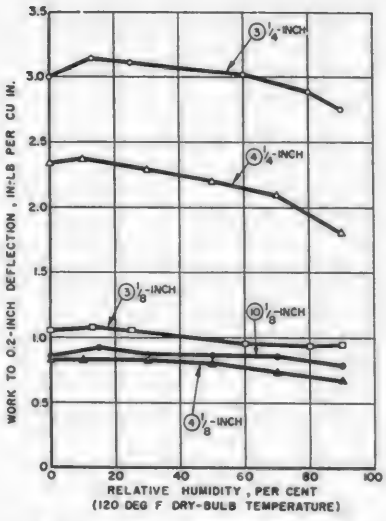

Fig. 23.—Effect of relative humidity conditioning at 120° F. on work to 0.2-inch deflection for several treated, wet-process hardboards.

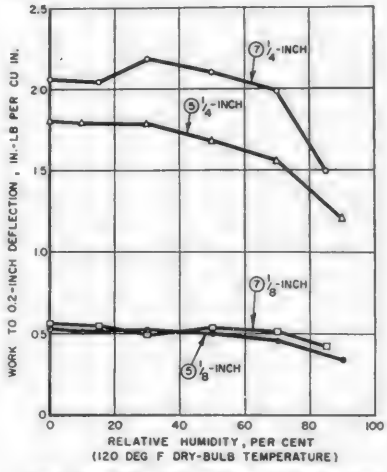

Fig. 24.—Effect of relative humidity conditioning at 120° F. on work to 0.2-inch deflection for several untreated, semi-dry process hardboards.

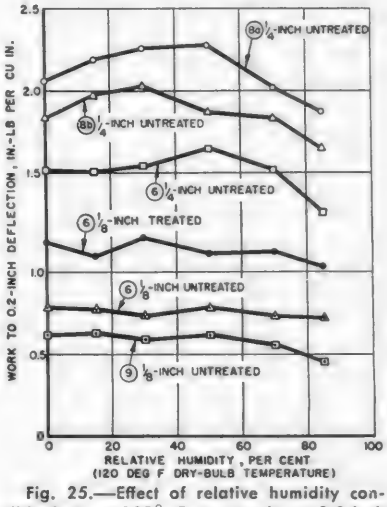

Fig. 25.—Effect of relative humidity conditioning at 120° F. on work to 0.2-inch deflection for several dry-process hardboards.

Fiber alignment does cause significant differences in the flexural properties of some types of hardboard. Consequently, fiber alignment should be considered in any sampling plan used to give a reliable property evaluation. The differences in flexural properties between the two major directions (parallel and perpendicular to machine direction) are not large enough to justify separation in use requirements.

Interactions between conditioning and machine direction: For the five properties involved in this study, only 6 out of a possible 125 significant interactions between conditioning and machine direction were observed; one for modulus of rupture, three for modulus of elasticity, one for work to maximum load, and one for work to 0.2-inch deflection. Interactions were found significant in only 7 per cent of the possible total. Since the level of significance used was 5 per cent, a significant statement could be expected to be declared in 5 per cent of the analyses. The small number of significant interactions found suggests that differential behavior between the two directions is not important in the flexural property evaluation of hardboard.

Summary

Twenty-five types of commercial hardboard were included in this study, representing ten different companies with treated and untreated boards in ⅛- and ¼-inch thicknesses. These boards also represented three distinct manufacturing processes — wet, semi-dry, and dry. The hardboard specimens were conditioned at various relative humidities to an equilibrium moisture condition and then subjected to a static bending test. Moisture content and the following flexural properties were determined: modulus of rupture, modulus of elasticity, work to maximum load, and work to a 0.2-inch deflection. A total of 1,500 static bending test specimens was used. The test data were analysed statistically as a factorial experiment in randomized blocks.

The several types of hardboard came to different equilibrium moisture contents, with the treated boards reaching the lowest moisture content. In general, the hardboard reached equilibrium moisture contents of 50 to 60% that of wood for the same temperature and humidity conditions. At relative humidities of 85 and 90 per cent and 120° F. dry-bulb temperature, the hardboard reached moisture contents from 9 to 12 per cent. Frequent weighings indicated that the ⅛-inch untreated boards were the first to approach equilibrium at any condition, followed by the ¼-inch untreated boards, with the treated boards of both thicknesses the last to reach equilibrium.

Modulus of rupture, modulus of elasticity, and work to 0.2-inch deflection increased while work to maximum load decreased as the moisture content of the boards decreased. The statistical analysis showed that of the 25 types of boards studied, modulus of rupture was affected significantly by conditioning in 23, modulus of elasticity in 24, work to maximum load in 17, and work to 0.2-inch deflection in 23 types.

Maximum bending strength (modulus of rupture) was reached between 30 per cent relative humidity and oven-drying conditions. Stiffness (modulus of elasticity) followed the same general pattern as modulus of rupture. The in-

Table 3.—COMPARISON OF AVERAGE FLEXURAL PROPERTIES OF HARDBOARD BY OVEN-DRYING AT 212° F. FOR 3 AND 17 HOURS.

Board type	Modulus of rupture		Modulus of elasticity		Work to maximum load		Work to 0.2-inch deflection	
	dried 3 hours Psi*	dried 17 hours Psi*	dried 3 hours Psi*	dried 17 hours Psi*	dried 3 hours In.-lb/cu in.†	dried 17 hours In.-lb/cu in.†	dried 3 hours In.-lb/cu in.†	dried 17 hours In.-lb/cu in.†
2	4,992	5,835	483	545	4.04	3.85	1.62	1.84
3	4,213	4,437	430	440	3.54	3.94	0.58	0.60
4	4,544	4,923	450	488	3.60	4.07	1.66	1.76
5	5,568	5,561	599	612	4.31	4.98	0.68	0.71
6	4,940	5,099	561	587	2.94	3.09	1.95	2.03
7	7,485	7,630	777	836	5.08	4.90	0.94	1.02
8	7,370	7,468	743	802	4.64	4.20	3.00	3.14

*Pounds per square inch.
†Inch-pounds per cubic inch.

crease in bending strength and stiffness of the boards conditioned at low relative humidities was accompanied by a loss in work to maximum load because of the embrittlement of the boards attended by loss of moisture. The general pattern of behaviour of the boards in work to 0.2-inch deflection was similar to modulus of elasticity.

The statistical analysis showed considerable variation in flexural properties among individual boards of the same type and demonstrated that the majority of types of hardboard studied possessed directional properties.

Oven-drying hardboard for extended periods of time improved the flexural properties because of the baking effect.

Appendix

Time-temperature effect of oven-drying: An exploratory study was designed to evaluate the effect of oven-drying on modulus of rupture in seven types of commercial hardboard. This study was carried out to evaluate the wisdom of oven-drying test specimens prior to conditioning at various relative humidities. The first group of test specimens was left in the oven at 212° F. for 17 hours. After testing, it was noted that there was little or no decrease from the strength of the hardboard conditioned at 13 per cent relative humidity level to the strength after oven-drying; in fact, several types of boards increased appreciably in strength, probably because of the baking effect.

It was decided to re-run the oven-dry series to evaluate the time-temperature effect on flexural properties of boards in oven-drying. Specimens for the oven-dry check run were selected in exactly the same manner as were the original oven-dry specimens. The specimens were left in the drying oven at 212° F. until they reached equilibrium, which required about three hours. The strength values obtained after oven-drying the specimens for three hours as compared to oven-drying for 17 hours are shown in Table 3.

Oven-drying hardboard specimens for periods longer than required to reach a constant weight increased the values for flexural properties in nearly all tests. For this reason, all the specimens for the project which were assigned to the oven-dry conditioning level, were removed from the oven as soon as they reached a constant weight.

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A Hydraulic Test Facility for Timber Structures[1]

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A new structural test unit at the Purdue University Wood Research Laboratory consists of a structural floor slab, steel holding brackets, and a hydraulic system for applying load forces to full-scale specimens. Its reported advantages include immediate detection of specimen failure, uniform loading, simplified instrumentation, multiple load directions, repeated loads at short intervals, and space economy.

A NEW STRUCTURAL TEST UNIT has been developed and installed at the Wood Research Laboratory, Purdue University. The facility consists of a structural floor slab, steel holding brackets, and a hydraulic system for applying load forces to full scale wood structural test specimens. Main details of the slab were obtained from designs originated at the Agricultural Engineering Department, Iowa State College. The load system was designed and built within the Purdue Wood Research Laboratory.

The universal nature of the basic equipment allows the setting up of tests of many types. Fig. 1 shows a 36-foot truss being subjected to a simulated uniform snow load. Wall reactions are provided by steel brackets adjustable along the tee slots for any span up to 40 feet. Load is applied by double acting hydraulic cylinders which are also fastened to the floor by adjustable brackets. The hand pump unit, shown in the upper left portion of the picture, can supply working pressures up to 1500 psi to either side of the cylinders to generate pushing or pulling forces up to 4000 pounds per cylinder. In the case shown, the cylinders all push to apply test load and are connected on the pull side only for the purpose of rapid retraction to change specimens.

The truss rides between roller supports below and ball bearing restraints

[1] A contributed paper, Journal Paper No. 914, Purdue University Agricultural Experiment Station, Lafayette, Indiana.

The Author: Stanley K. Suddarth received B.S., M.S., and Ph.D. degrees from Purdue. From 1951-54, he was associate director of Purdue Bomb Effectiveness Research Project sponsored by U. S. Air Force. He has been engaged in wood research in Dept. of Forestry since Sept. 1954.

above, Fig. 2, which assures freedom of motion in the load direction while, at the same time, restricting motion in unwanted directions.

A close approximation to uniform loading is obtained through the use of specially designed load shoes which apply equal forces at 1-foot intervals, Fig. 3. Pointed screws project through the contact plates. These provide the necessary resistance to slippage along the upper chord of the truss as force is applied.

Details of the floor slab are shown in Fig. 4. Bolt stations, Fig. 5, were placed on a 2-foot module rather than 3-foot as in the original Iowa design and the steel ratio was increased over that of the Iowa design, otherwise the details of slab construction are relatively unchanged. The 2-foot spacing is recommended if the uniform loading system for beams and trusses is to be used since holding brackets may then be fastened directly to the bolt stations. On the other hand, the load cylinders can be placed at any point on the floor through the use of auxiliary support bars, Fig. 6. Thus the test floor is a coordinate plane upon which loading can be performed in any direction and along any line of action.

Details of the load cylinder assembly are shown in Fig. 7. Mild steel was used in all parts with the exception of the levelling guides, which are oak, and the cylinder pin, which is drill rod. All assemblies were electrically welded. Slight deformations occurred due to welding stresses but were not sufficient to require corrective machining. The spacer plate was inserted below the cylinder bracket to allow the use of the auxiliary support bars mentioned above without shifting the level of the loading cylinder axis.

The reaction brackets, Fig. 8, were heavily constructed to resist deformation under the large forces involved in the loading of long trusses and beams. The bracket shown was designed for use with the double tee

Fig. 1.—Thirty-six foot span, 2:12 pitch roof truss under test.

slots and provides for lateral adjustment along the 1- x 6-inch horizontal plate to allow for a variety of set-up requirements. The stirrups are made of 8- x 8- x $\frac{5}{8}$-inch angle reinforced

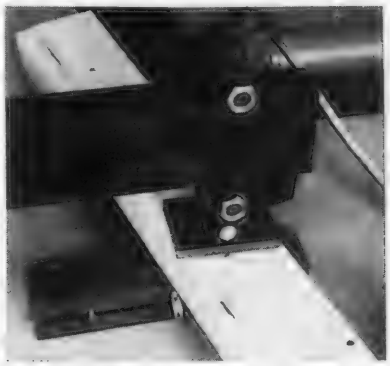

Fig. 2.—Rollers and bearings allow free motion of the test member in the direction of loading.

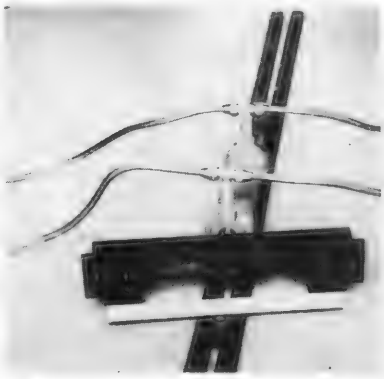

Fig. 3.—Loading cylinder assembly showing spaced contact plates with wood gripping points.

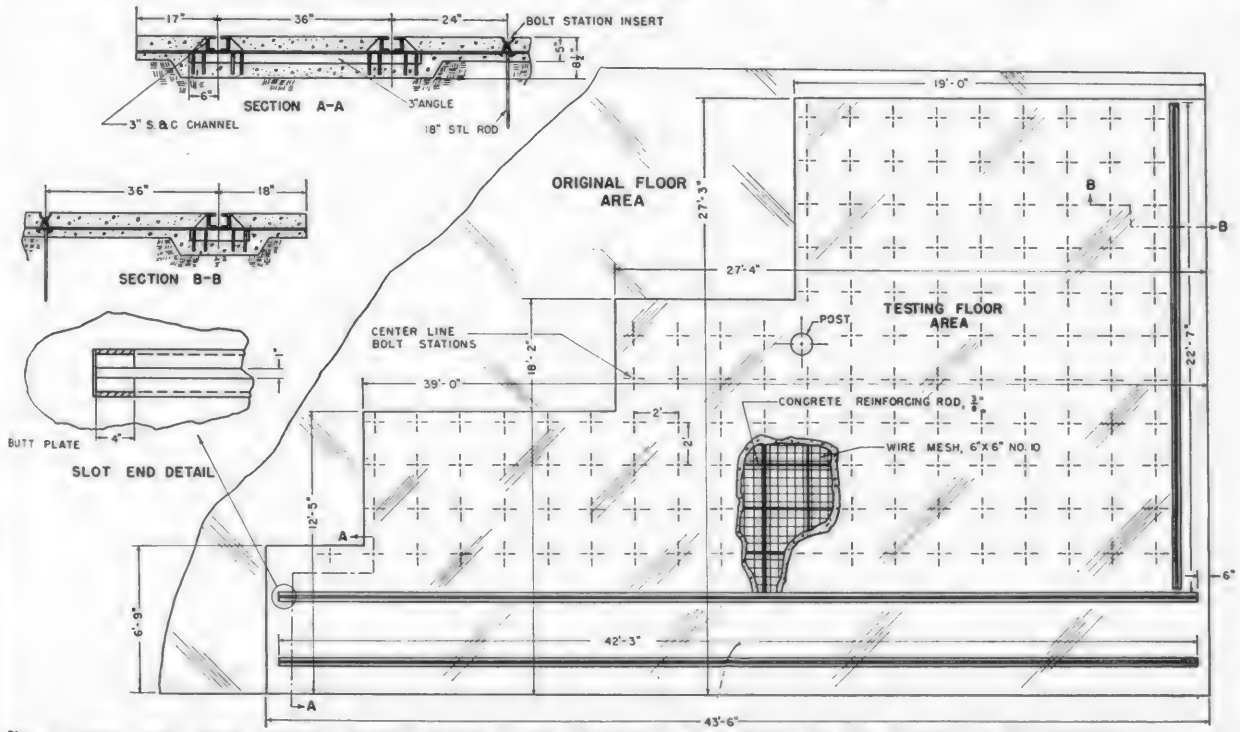

Fig. 4.—Floor slab detail. Existing facilities control overall dimensions. Perpendicular tee slot expands set-up combinations.

Fig. 5.—Bolt inserts and reinforcing before concreting. Entry slots of the malleable iron inserts were filled with paper to guard against complete filling. These inserts were located with a magnet and chipped clean after concreting.

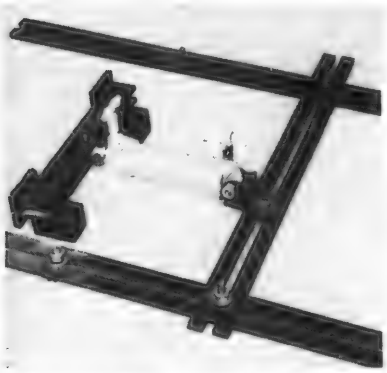

Fig. 6.—Auxiliary cross bars allow location of the cylinder bracket at any point on the floor. Width of the half-inch thick cross bars is dictated by the forces involved in a particular test.

with ¾-inch plates and are held in place by ½-inch cap screws.

The upper restraint assembly, Fig. 9, has a 3-inch channel for its main member being held in the tee slot by a bracket at the rear and tee bolts at the front. The roller bearing head can be positioned as desired along the channel.

The hydraulic pressure system is shown schematically in Fig. 10. A simple design was used for this first unit. The parts, except for gauges, tubing and fittings are war surplus items. The 6-inch gauges are first quality and gave consistent results during calibration trials.

Each cylinder was placed in a universal testing machine and calibrated against the high and low pressure gauges for both pushing and pulling actions. Variation of forces at 150 psi (low pressure gauge) and 1000 psi (high pressure gauge) was in the order of 10 per cent. All values were averaged into a single set of calibration curves for use with the uniform loading of trusses. It is felt that the accuracy thus obtained is equal to or better than that obtained through the use of blocks, bricks, or other weights for truss testing since these, even when matched in weight, must be applied in such a way as to create nonuniformities of loading. Individual cylinders can be matched in sets for more precise requirements.

Although only one pressure system is in current use, no difficulty is foreseen in introducing others to operate independent sets of cylinders for the purpose of superimposing wind and other loads on the structure when required.

The principal features of this facility for making short duration, full-scale strength tests may be summarized as follows:

Safety: Failure of any part under test causes movement of at least one cylinder in the system which, in turn, causes the fluid pressure to drop immediately. Thus movements are restricted to short distances without danger to operating or observing personnel.

Immediate Detection of Failure: The behavior of the system which provides safety also halts complete destruction of the element under test. This is a distinct advantage over the gravity loading systems which often confuse the study by complete specimen destruction. Expensive specimens can be patched for further study and, in some cases, additional changes can be made to study their effects independently of between-specimen variation.

Uniform Loading: Although this is only one type of possible loading, it is of utmost importance. Snow, for instance, produces a uniform load which must be duplicated in any complete roof test. The loading elements shown above allow ready adjustment for a variety of spans, slopes, and positions.

Instrumentation: The task of placing dial gauges and other measuring devices is simplified in plane testing. Simple instrument brackets can be attached to bolt stations, tee slots, or held in place by weights, thus eliminating the need for complex vertical superstructures for measuring devices. The absence of violent movement at failure is also advantageous, delicate instruments can be left in place in

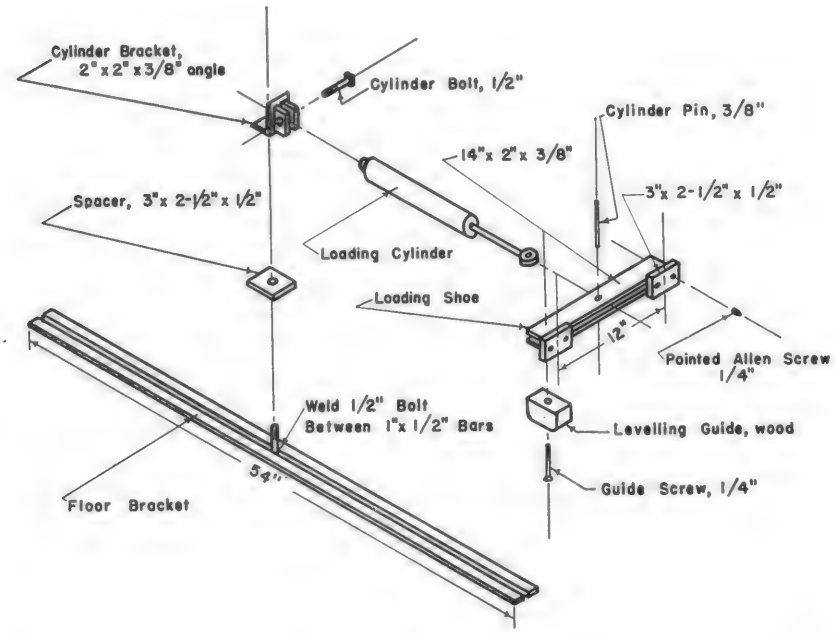

Fig. 7.—Loading cylinder assembly.

Fig. 8.—Reaction brackets. These can be located at any position along the tee slots.

Fig. 9.—Upper restraints. These are movable along the slots to occupy critical positions in preventing buckling of members under load.

many cases, to record vital information as failing loads are approached.

Multiple Load Directions: Any direction of loading can be used within a plane parallel to the slab. Further, different load magnitudes can be used in any of the directions through the use of factor levers, different cylinder sizes, or different pressure systems. Similar features can also be realized with pulley and cable systems loaded by weights, but these become cumbersome in changing from one setup to another. Loading in a third dimension is not out of the question; the floor slab is sufficiently strong to allow erection of vertical steel cylinder supports or reaction brackets for loading of wooden elements.

Repeated Loads: Successive application of load requires but two to three minutes to complete. Pressure is obtained by the use of the hand pump at any desired rate and can be quickly released. Thus an entire day's work using bricks or blocks for repeated uniform loading can be duplicated by hydraulic loading in a relatively short time. Studies of the fatigue behavior of composite structural elements are brought within easier reach because of the economy of time and effort in obtaining data.

Space Economy: The floor slab, which is the backbone of the test facility, can be used as a normal floor during non-testing periods. Where laboratory space is important, this feature provides added room for fabrication, storage, or other experiments at times when structural tests are not in process. The setup shown in Fig. 1 can be assembled in three hours and completely dismantled in one hour.

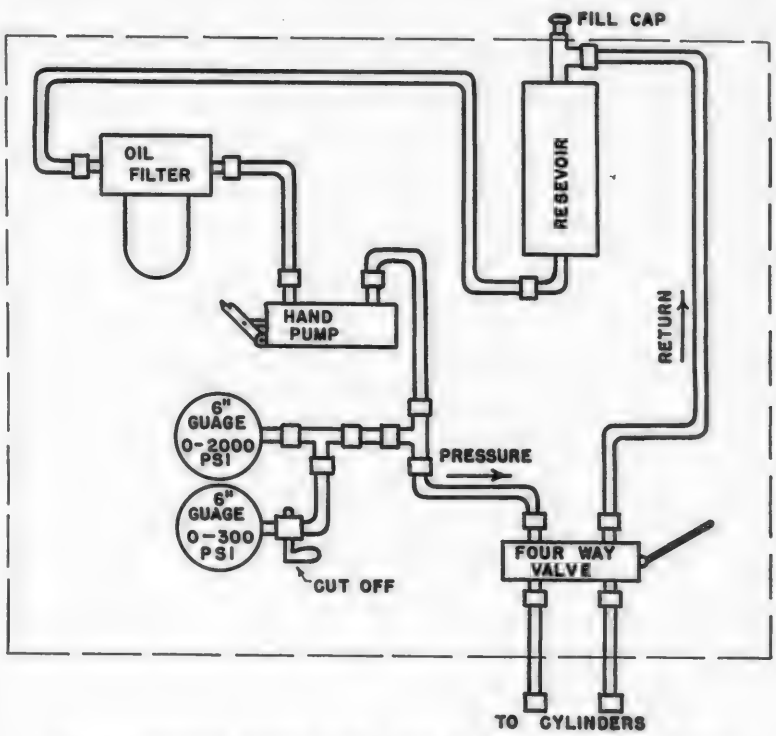

Fig. 10.—Schematic drawing of the hand pump hydraulic pressure system.

As new test requirements arise, supplementary brackets and fittings will be added. Tests of beams, panels, and rigid frames are planned in conjunction with other research projects under way at the Purdue Wood Research Laboratory. The addition of a power-operated, electronically controlled hydraulic system is also under consideration. Such an accessory would open new fields of testing by introducing variable loading to more efficiently study fatigue, creep, and other phenomena in full-scale wooden structural elements.

Handbook for Small Sawmill Operators

How to Attain and Maintain Accuracy of Cutting

Part II. Saws

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For a sawmill to function properly, the saw must be of the proper type, correctly tensioned for the speed at which it is being run, and the cutting teeth must be in good condition. Factors to consider in selecting the proper saw are discussed and a detailed explanation is given of fitting the saw.

THE HEADSAW IS, of course, the heart of a sawmill headrig. If it is not functioning properly the mill is not functioning properly. There are many difficulties that may be experienced with a saw if it is not of the proper type, correctly tensioned for the speed at which it is being run, and with the cutting teeth in good condition. Many of the troubles that are blamed on the saw, however, are caused by malfunctioning of other parts of the mill. Some of these, like the mandrel not running true, saw collars not correctly machined or kept clean, speeds not sustained, and carriage not running straight and smooth, have already been mentioned. Others will be under "Mill Setup" and "Trouble Shooting".

Types of Saws

There are two general types of circular headsaws. They are solid-tooth and chisel-tooth (or inserted-tooth) saws. The solid-tooth saws are of one-piece construction, with the teeth milled directly in the saw plate. Teeth on this type of headsaw are usually swaged rather than spring-set (Fig. 14-A). The more commonly used saws at small sawmills, however, have sockets around the rim for the insertion of chisel type teeth and shanks or holders (Fig. 14-B).

The solid-tooth saws have a lower initial cost. However, they require more expert maintenance and, furthermore, as they are sharpened and the gullets deepened, they gradually decrease in diameter until they are no longer suited for use as head saws. Consequently solid-tooth saws are generally used only on large circular mills where the maintenance they need is available and alternate uses can be made of them when they lose diameter.

The chisel-tooth or inserted point type of saw is the overwhelming choice of small circular sawmill operators throughout the country. Maintenance problems are generally very much simpler as new teeth can be easily installed when the old ones are worn out or have become broken. These new teeth come already sharpened and swaged to various widths from the factory. Different alloys are available also for different types of sawing. Such alloy or electro-coated bits give excellent service in resaws and edgers, but they stand up to dirt and grit in headsaw use no better than ordinary bits. Furthermore, they generally cannot be swaged, and many of them cannot be filed. For use with debarked logs, however, they may give a better account of themselves, despite their higher first cost, than ordinary bits. With clean logs they should require resharpening very infrequently.

Selecting the Proper Saw

The choice of a saw to be used on a mill will involve a decision as to the diameter, thickness or gauge of plate, type and number of teeth, and the tensioning needed. The diameter of the saw chosen should generally be the smallest that will saw the logs received at the mill. Generally, since cuts are rarely made through the center of the log, the maximum size of the log that can be cut will be about four inches greater than half the diameter of the saw used. When big logs are to be cut, installation of a top saw on the headrig (see Fig. 5) may be more economical than trying to cut them with a single sawrig. When ordering be sure and advise the diameter of the saw needed.

Gauge and Number of Teeth: The thickness or gauge of the saw blade will depend on the type of material to be cut, diameter of the saw, rate of feed expected to be attained, R.P.M. of the saw, and experience of the operator.

Circular chisel-tooth or inserted point head saws are usually ground so that they are a gauge thinner at the rim than at the center. On special order, saws will be ground two gauges thinner at the rim (see Table of Gauge Equivalents in "Appendix"). This makes for strength and rigidity with a minimum of sawdust loss. For very easy work, a 9 x 10 gauge saw might be used. The best gauge for chisel-tooth or inserted point head saws 48-inch or less in diameter which are

PREFACE

The Handbook for Small Sawmill Operators was prepared by the Logging and Milling Committee of FPRS at the request of Sectional Committee B–66 of the American Society of Mechanical Engineers.

The material has been divided into six parts being published serially in the Forest Products Journal. It will be available later as a separate bulletin from the Standards Department of ASME, 29 West 39th St., New York 18, N. Y.

Publication of this Handbook by FPRS and ASME is not to be construed as establishing any new dimensional standards for lumber. Such standards are promulgated by the American Lumber Standards Committee for softwoods and by the National Hardwood Lumber Association for hardwoods. It is designed specifically to show the small sawmill operator how he can produce lumber to those standards more economically and most efficiently.

Acknowledgment is due many people, representing the several groups interested in the small sawmill business in various ways, for the constructive help and advice given in this handbook compilation. The Committee is very grateful to all those who helped so generously.

FRED C. SIMMONS, *Chairman*
FPRS Logging and Milling Committee

intended for fairly easy sawing is 8 gauge at the center and 9 gauge at the rim. For harder service, such as sawing hardwoods or very knotty softwoods, a 48-inch saw which is 7 x 8 gauge usually proves better. For saws larger than 48-inch in diameter, a 7 x 8 gauge is about right for the small sawmill.

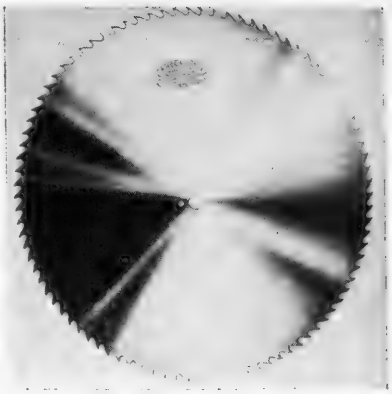
Types of Teeth: A considerable variety of inserted teeth are available from the different manufacturers (Fig. 15). The #2½ or style F patterns are the smallest in size and are recommended particularly for sawing knotty small softwoods. For this type of cutting, the saw must have enough teeth so that it will not dodge or run out of the cut. The knots must be cut through and when the saw has too few teeth, each tooth hooks over the knot so far it cannot be cut without undue strain on the rim of the saw. These teeth, however, have restricted gullet capacities for sawdust.

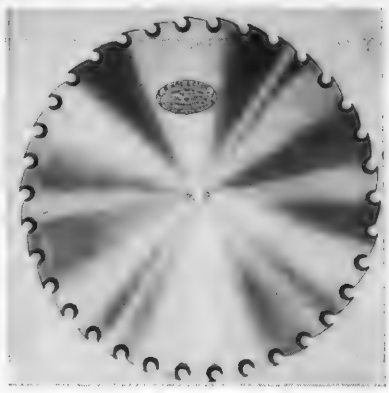
The other common tooth patterns, including No. 3, B, C, and D, (Fig. 15, A, B, and C) have larger gullet capacities and consequently can be run at a higher feed rate per tooth or per revolution. Heavier, more nearly cubical sawdust is made, which chambers better in the gullets and consequently there is usually less trouble with it slipping by and causing trouble in the cut. These bigger teeth usually use less power and consequently give higher productivity. A good feed rate to aim for is a tenth of an inch per tooth on an average 10-inch deep cut. (This means that a 56-inch saw with 50 teeth should be fed at a rate of five inches per revolution of the saw on this depth of cut, a 46-inch saw with 40 teeth could be fed at the rate of 4 inches per revolution, etc.) Six less teeth than the diameter of the plate is about the average for these tooth patterns, but saws can be ordered with several more or less teeth than this.

A table giving the degree of interchangeability of insert point saw teeth and holders of different manufacturers is given in the "Appendix."

Tension: The tension put into a saw plate is very important because the saw has to be tensioned differently to run straight at different speeds. The rim will stretch when the saw is up to speed from the centrifugal force of rotation. Consequently, the central part of the saw plate must be "opened up" to the proper degree by hammering, to provide for this expansion. The faster the saw is to be run, the more opening up it needs. Thinner saws need more than thicker ones, and larger diameter saws more than smaller ones. Consequently, the speed at which a saw will be run has to be specified in ordering. Be sure to state also whether the mandrel runs cold, warm, or hot—this is very important. The mandrel should run cool for best results but with the conditions under which many portable saw mills are operated, they often run quite warm which has an unfavorable effect on the operation of the saw unless a special job of tensioning is done. Heating causes the center of the saw to expand more than it should. The effect of a warm mandrel can be offset in most cases when hammering by leaving the center somewhat stiffer.

When in doubt as to just what saw is needed, furnish the manufacturer with full particulars as to the power available, speed of saw, rate of speed, and type of logs to be sawn.





—Photos courtesy R. Hoe & Co.

Fig. 14.—Circular mill saws. Solid tooth saw, left; insert tooth saw, right.

Fitting the Saw

It does not pay to run a dull saw. If the logs are dirty or difficult to cut, it will be necessary to sharpen the saw five or six times a day. This can be reduced by provision of some means to clean the logs before they are put on the carriage, such as a high pressure spray, or log pond. A "grit gouger" or "log cleaner" which routs out a path through the bark on the top of the log ahead of the saw is especially valuable to small mills (Fig. 16). With the use of one of these devices, it may be possible to get by with only the normal two fittings a day.

How to File Saw Bits: In filing saw bits, always keep in mind that the cutting edge must be straight across and the corners must be kept sharp. If the cutting edge is high on one side it will cause the saw to lead in that direction. If corners are dull or rounded, the clearance is affected, there is a good deal of friction, and the saw will run hard and be likely to go in and out. Keep the saw sharp. How often it is necessary to sharpen depends a good deal on the nature and condition of the logs being cut, but you must keep the saw sharp to obtain satisfactory results. Never try to lead the saw by filing the bits high on one side. Two wrongs do not make a right—the only way to adjust the lead is by swinging the mandrel.

—Top and center photos courtesy R. Hoe and Co.; lower photo, courtesy Henry Disston & Sons.

Fig. 15.—Common types of insert saw teeth and holders. Top, styles 2½ and 3; center, styles B, D, and F; lower, type C (double bali).

The correct angles for filing most types of insert point teeth are shown in Fig. 17. For smaller diameter saws, the back clearance may be a little greater, and for the larger ones it may be a little less than that shown.

A file guide (Fig. 18) is available that makes it easier to do a uniform and accurate job of hand filing.

—Photo courtesy Edwards Machine Co.

Fig. 16.—Log cleaner or "grit gouger" in use. (The protective screen between saw and operator has been removed to show details.)

Hand operated rotary saw bit filers and electric saw bit grinders are also available. The electric grinder can be supplied with wheels for sharpening standard or hard bits. If unusually smooth cutting is desired, a side dressing tool can be purchased or one can be easily made at the mill with a file, square piece of wood, and four wood screws (Fig. 19).

It is not necessary to do a lot of filing to keep the teeth in good condition. Use a file with round edges as illustrated in Fig. 20 to prevent filing nicks in the throats under the teeth, which will keep the sawdust from chambering properly. These nicks also provide a weak spot which may lead to breakage of the tooth.

It is not injurious to the saw to *swage teeth* slightly with an upset swage (Fig. 21) provided a hammer of not over three-quarters to one pound in weight is used. Be sure tooth is filed to the correct angle before swaging. The point of the bit should not be too blunt to enter fully into the V of the swage, so it should be filed first so that it fits well into the V, before swaging. Strike light blows. Use the die with the convex face first, to spread out both corners of the tooth. Then use the die with the flat faces to square the point of the tooth. Be careful not to hold the swage too low. In fact it is desirable to raise the edge a little, say two or three thousandths of an inch, because the tooth while cutting wears mostly on the face. It also wears a little on the top or back, near the point of the cutting edge, which puts undue strain on the rim of the saw, causing it to pull hard. This is eliminated if the points of the teeth are raised.

In order to insure against damage to the sockets, many saw filers remove the tooth from the saw for swaging, and put it into a saw segment, clamped in a vise. Others are successfully using a roller type swage (Newell type) especially adjusted to fit chisel-tooth or inserted point teeth instead of an upset swage.

Changing the Teeth: Place a cup of oil, together with the new teeth to be inserted, conveniently near you at the back of the saw; place the wrench in the holder; remove the holder from the socket; clean out and oil the socket and free it from dust and pitch; pick up a new tooth, dip the grooved segment into the oil, place it in position on the holder, hold it firmly and evenly with the sides of the blade, and at the same time press the wrench downward until the stops meet. Do not use undue force. Let the stops meet lightly, and when the tooth is in place no further pressure is necessary.

If the tooth after being inserted, inclines to one side of the holder, use the wrench as an anvil on one side, and hammer on the other, to tap the tooth and force it into the proper position. Tooth and holder must be in line and must be kept in line to secure good results.

If a *tight tooth* refuses to move with the wrench, never hammer the wrench or the tooth, but place a blunt cold chisel on the heel of the holder, being careful not to touch the saw plate, and tap lightly with the hammer. This will start the tooth and holder and enable you to remove them easily with the wrench.

Width of Cutting Edges: Nothing is gained by attempting to use inserted teeth too narrow on the cutting edge. For best cutting in softwood, teeth should be, when new, 1/4 inch wide for 10-gage saws, 17/64 inch for 9-gage, 9/32 inch for 8-gage, 5/16 for 7-gage. For cutting hardwood or frozen softwood, the teeth can be 1/64 inch narrower than these recommendations. In fact, with frozen wood short points do better than points of full length. Teeth which have been discarded in the summer can be used to good advantage in the winter. Select the used teeth in sets of one

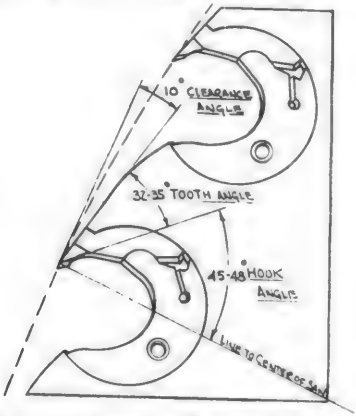


Fig. 17.—Correct angles for filing most types of insert teeth.

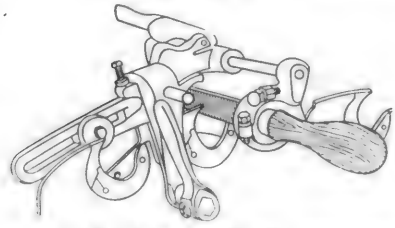


Fig. 18.—A file guide for sharpening insert point teeth. The stop insures that each tooth is filed the same amount and the guide insures that the teeth are filed to the same angle and straight across.

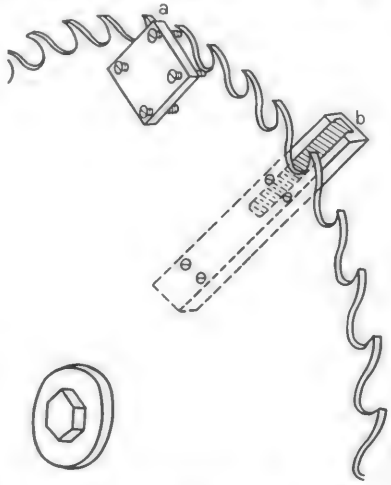


Fig. 19A.—a. Homemade side clearance gauge; b. side dressing tool.

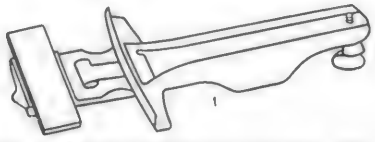


Fig. 19B.—Commercial side dressing tool.

length. File the corners good and sharp, swage them a little, put them otherwise in good shape, and you will be surprised at the results.

Otherwise teeth much narrower than the recommendations given above will be too narrow to clear the saw blade properly, after one or two filings, resulting in the heating or buckling of the saw blade and causing trouble generally. Swaging teeth will restore them to the proper width of cutting edge, provided they are not worn too much.

Care of Holders: Holders are made so that they are one and one-half gages thicker under the head than the saw-plate proper, thus forming a flange which keeps the cut clear of dust (Fig. 22). This is particularly necessary in cutting frozen timber. Recently several new types of holders or teeth have come on the market which have lips or protuberances in the throat to divert the dust and keep it from being thrown down so violently to the bottom of the circle that it slips out of the gullet.

Never Run the Saw with Loose Holders: If holders are allowed to become loose, there will not be sufficient pressure at the rim of the saw and the tension at the center will seem to be increased. The saw will not run properly.

The remedy is to replace the holders if they are worn thin. If they simply become "set" or compressed take them from the saw, lay them on an anvil, and strike them on both sides at the points indicated by the X marks in Fig. 24 until they are expanded sufficiently to hold the teeth securely. Be careful not to hammer more on one side than the other, and do not bend the holder. Never hammer the saw blade or the V-ed portion of the holders.

Through long usage, the socket on the saw holding the shank may become worn. To overcome this most manufacturers make two extra sizes of holders, one 1/64 of an inch oversize and the other 1/32 of an inch larger.

Tensioning Saws: No attempt will be made to give instructions for *retensioning* circular saws. This is a highly technical job and local saw shops and the various saw manufacturers are set up to do it correctly, on fairly short order, at a reasonable cost. They usually also guarantee that a saw will run correctly after it has been rehammered. Consequently it is recommended that if a saw blade becomes kinked or strained in use; if the speed at which the mill runs is changed materially; or if, after long use retensioning becomes necessary, that the saw be sent back to the factory or to a reputable local "saw doctor" for retensioning. Whenever inserted tooth saws are returned to the factory or other saw shop for repairs, leave all points and holders in place. Also:

1. State the "hand" of the mill. (If the log or carriage is on right side from the sawyer's position, it is a right-hand mill. If on the left, it is a left-hand mill.)
2. Give the speed in and out of the cut. (Do not guess or figure from the pulleys. Use a speed indicator.)
3. Give the greatest feed in inches per revolution.
4. State the kind of timber being sawed.
5. Give the horsepower available and type of drive.
6. State whether the mandrel runs warm, hot or cool.

—Photo courtesy R. Hoe & Co.

Fig. 20.—Correct file for use in sharpening saw teeth. (Note round edges.)

—Photo courtesy Henry Disston & Sons

Fig. 21.—Correct use of upset swage. Use the die with the convex face first to spread the points of the teeth (H). Swage out both sides the same. Next use the die with the flat faces to square up the point of the tooth.

Fig. 22A.—Holders with flange worn round will not chamber sawdust properly.

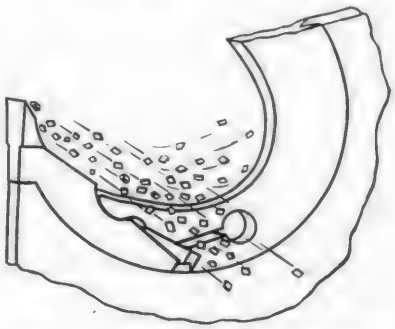


Fig. 23.—Holders with the flange worn completely away allow the sawdust to slip by. Such holders do not have the necessary strength to hold the tooth properly. They should be thrown away and new holders substituted.

—Drawing courtesy Simonds Saw and Steel Co.

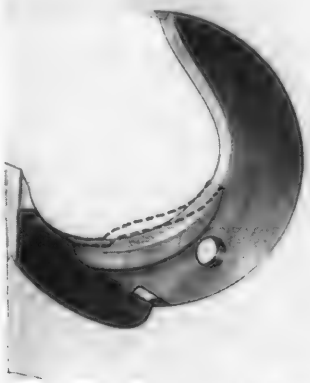


Fig. 22B.—The rounded edge can be squared up with a half-round file so that sawdust will be retained in the gullet.

—Photos courtesy Simonds Saw and Steel Co.

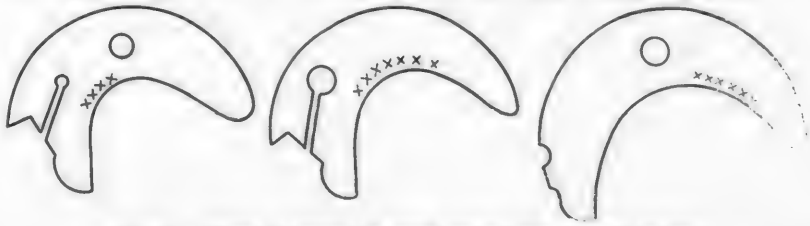


Fig. 24.—Where to hammer to spread various types of tooth holders.

Effect of Moisture Content on the Performance and Appearance of Resorcinol Glue Lines in Laminated Oak Lumber[1, 2]

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Study revealed that in laminating red oak with a warm-setting resorcinol resin, it is possible to produce glue joints having satisfactory strength when the moisture content of the lumber ranges from approximately 4 to 22 per cent. For exterior service, the moisture content of the wood at gluing must be between 4 and 14 per cent. The depth of adhesive penetration and the thickness of the final glue line are dependent upon the moisture content of the wood at the time of gluing.

IT IS COMMON PRACTICE for adhesive manufacturers to specify the moisture content to which wood should be conditioned prior to gluing. This is done so that the user may obtain glue lines that: (a) develop maximum strength by providing a condition for which the glue was designed and formulated, and (b) have a minimum of residual stress under service conditions.

The relationship of wood moisture content to glue line performance has been studied by the various adhesive manufacturers and by the U. S. Forest Products Laboratory in order to develop production procedures to be used with certain adhesives. It was believed worthwhile to undertake a study that would contribute information on this subject and seek to define the effect of wood moisture content in terms of not only joint strength but also in terms of the physical characteristics of the resulting glue line.

Recent work on laminating, especially that having to do with the small ship program of the U. S. Navy, has caused considerable interest in wooden assemblies composed of red or white oak lumber bonded with a resorcinol resin adhesive. This interest plus the fact that such combinations appear promising in other applications led to the choice of materials for the study being reported. Test specimens were fabricated by laminating straight-grained, defect-free, red oak with a two-component, resorcinol-formaldehyde resin, Penacolite 1260, manufactured by the Koppers Company, Inc., Pittsburgh, Pa.

Blanks ¾ by 2¼ by 12 inches were cut from random-width, random-length, kiln-dried red oak lumber. Defect-free, straight-grained pieces of essentially equal specific gravity were paired. In order to prevent a bias in the test results due to specific gravity, the 17 pairs that were to be conditioned to each of the six moisture content groups were selected using a table of random numbers. Each of the six groups was conditioned in a dry kiln to one of the following nominal moisture contents; 0, 4, 8, 14, 22 and 50 per cent. After conditioning, the pairs were glued together following the specifications of the adhesive manufacturer. An initial gluing pressure of 200 psi was applied by means of rocker-head clamps. The adhesive was cured in a dry kiln at a dry bulb temperature of 120° F. with the wet bulb set to maintain an equilibrium moisture content equal to the moisture content of wood at the time of gluing (Table 1).

Table 1.—AVERAGE MOISTURE CONTENT OF LAMINAE AT TIME OF GLUING AND CONDITIONS OF ADHESIVE CURE

Moisture content at assembly	Conditions of cure	
	Dry bulb	Wet bulb
Per cent	Degrees F.	Degrees F.
1.10	120	70
4.18	120	84
8.07	120	100
13.79	120	112
21.81	120	118
51.13	120	120

Nominal moisture contents mentioned in the text are representative for each moisture content value. The actual moisture content of each group was obtained by placing an additional group of what may be termed "moisture content specimens" in the kiln with the laminae. These specimens were machined along with the laminae, and their green weight recorded when the laminates were assembled. They were then oven dried and their moisture content determined. Ten such determinations were made for each moisture content group and the average reported as the actual moisture content at time of gluing (Table 1). The moisture added to the wood by the application of the adhesive was computed and found to be less than 0.5 per cent.

Following the adhesive curing period, the assemblies were aged for at least one week before machining. Three block shear specimens, a glue study block, and a delamination specimen were obtained from each laminate (Fig. 1).

Strength in Shear

The block shear specimens were tested dry (moisture content at test ranged between 5 and 10 per cent) following the procedure outlined in A.S.T.M. Standard D905–49. The results of these tests are listed in Table 2. Prior to computing the average values of Table 2, the individual shear

[1] A contributed paper.

[2] Authorized for publication in the Journal Series of the Pennsylvania Agricultural Experiment Station as paper number *1962*.

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Table 2.—RELATION OF SHEAR STRENGTH AND WOOD FAILURE TO WOOD MOISTURE CONTENT AT TIME OF GLUING

Moisture content at gluing	Number of tests	Average shear strength adjusted to 12 per cent moisture content	Average wood failure
Per cent		Psi	Per cent
1.[illegible]	51	1759 ± 33	74 ± 12
4.[illegible]	51	1883 ± 62	94 ± 2
8.[illegible]	51	2308 ± 47	92 ± 2
13.[illegible]	51	2174 ± 44	89 ± 2
21.[illegible]	51	2187 ± 37	76 ± 2
51.[illegible]	51	1669 ± 41	42 ± 12

strengths were adjusted to 12 per cent moisture content by means of an alignment chart which was in effect a graphical solution of the exponential formula commonly used in making strength-moisture content adjustments.

A statistical analysis showed that the average shear strength developed by the nominal 8 per cent group is significantly higher than that of the other groups tested. No significant difference exists between the 14 and 22 per cent groups, while the strength of the remaining groups is significantly lower than the higher values developed by the 8, 14, and 22 per cent groups.

A comparison of the test results with the published strength in shear of red oak shows that the 4, 8, 14, and 22 per cent groups develop strengths higher than this value (Fig. 2). However, due to the mechanical differences that exist between the block shear test and the standard shear test used to establish the published value, the block shear values should be approximately 20 per cent higher than the latter.[8] If this basis is used in an evaluation of shear strengths, only the 8 per cent group is significantly higher than the published value plus 20 per cent. The shear strength of the 14 and 22 per cent groups is approximately equal to this value, while the 0, 4, and 50 per cent groups produce results that are significantly lower than the published value plus 20 per cent.

Table 2 and Fig. 2 show the trends in wood failure that were observed. Wood glued at a nominal 4 and 8 per cent moisture content gave essentially equal values that were significantly higher than the other groups tested. Wood failure in the 14, 22, 0 and 50 per cent groups was progressively lower in the order listed.

If a combination of the highest shear strength and highest wood failure is used as a basis of judgment, the 8 per cent group is superior. A more reasonable evaluation would be to accept all groups that produced a joint showing at least 75 per cent wood failure and a strength in shear equal to or greater than the published shear strength of red oak. On this basis, the joints formed with wood at nominal moisture contents of 4, 8, 14 and 22 per cent are acceptable.

[8] Murphey, W. K. and W. T. Nearn. 1955. The relationship of the block shear test to the standard shear test in the determination of the shearing strength of red oak parallel to the grain. Unpublished Report, School of Forestry, The Pennsylvania State University.

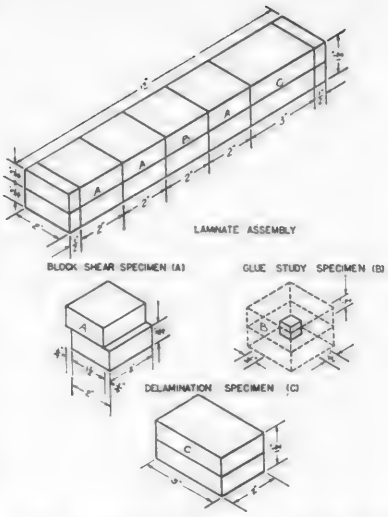

Fig. 1.—Laminate assembly showing the position and dimensions of: (A) the three block shear specimens, (B) the glue study block, and (C) the delamination specimen.

Delamination Tests

The blocks (Fig. 1C) which had been designated for the delamination study were immersed in water at room temperature for 15 days and dried at room temperature at an equilibrium moisture content of about 4 per cent for 6 days. This procedure was repeated three times. At the end of the third cycle, the total delamination was measured to the nearest 0.1 of an inch. Table 3 lists the amount of delamination expressed in inches of glue line delaminated and as a percentage of the total glue line present.

Table 3.—DELAMINATION RESULTING FROM ACCELERATED TESTS

Moisture content at time of gluing	Delamination*		Number of blocks cycled	Number of blocks showing delamination
Per cent	Inches	Per cent		
1.10	6.5	3.82	17	4
4.18	0.0	0.00	17	0
8.07	0.0	0.00	17	0
13.79	0.0	0.00	17	0
21.81	1.3	0.77	17	1
51.13	131.9	77.59	17	17

*Per cent delamination was determined as the total delamination in a particular group divided by the total glue line in this group, i.e. for 1.10 per cent group, per cent delamination $= \frac{6.5}{17 \times 10} \times 100 = 3.82$.

No delamination was observed in the 4, 8, and 14 per cent groups, while that occurring in the 22 per cent group may be considered negligible. It would appear that on the basis of the accelerated weathering tests, wood bonded at 4, 8, 14, and 22 per cent moisture content is capable of producing bonds suitable for exterior use. It was realized that although the accelerated test is indicative of the performance of the glue line, the results of such tests are not conclusive. Therefore, the delamination specimens were placed on the roof of the Forestry Building at Pennsylvania State University, University Park, Pa., and allowed to weather for a period of approximately one year. Table 4 contains the information obtained from these blocks following an exposure of this duration.

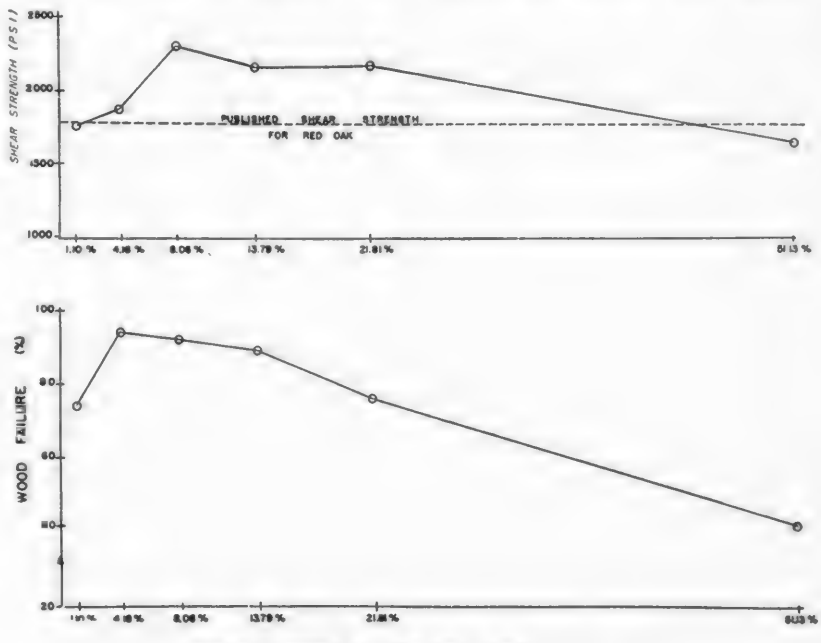

Fig. 2.—Average shear strength and wood failure for red oak when glued at six wood moisture contents.

Table 4.—DELAMINATION RESULTING FROM ONE YEAR WEATHERING TESTS

Moisture content at time of gluing	Total delamination		Number of blocks weathered	Number of blocks showing total delamination greater than 0.5 inch
Per cent	Inches	Per cent		
1.10	30.0	19.60	16	11
4.18	5.2	3.20	16	5
8.07	12.1	6.90	17	11
13.79	15.0	8.70	17	11
21.81	22.6	15.10	16	12
51.13	138.0	86.00	17	17

In the case of the 0 per cent and 50 per cent groups, the trend of delamination indicated in the accelerated tests has continued (Fig. 3). The 4, 8, 14, and 22 per cent groups which at the end of the accelerated weathering cycles showed no delamination now have a delamination of 3, 6, 8, and 15 per cent. If as a criteria for satisfactory performance it is required that the specimens show less than 10 per cent delamination, wood glued at 4, 8, and 14 per cent moisture content will qualify. Since this conclusion is somewhat different from that drawn from the accelerated tests, the exposure tests will be continued for at least one more year.

It is interesting to note that although 5 specimens in the 4 per cent group showed delamination, only 1 of the 5 showed a total delamination of greater than one inch. It might be pointed out that since all these blocks were fabricated under similar conditions with the exception of wood moisture content, it appears as though either the bond between the wood and the glue or the inherent quality of the glue line is adversely affected by the lack of moisture in the wood in the 0 per cent group and by an excess of moisture in the 22 and 50 per cent group. The magnitude of the stresses as a result of changes in wood moisture content from that of the wood at the time of gluing can hardly be the entire cause of delamination since the wood glued at 4 per cent has been subjected to considerable stress in the process of weathering.

Physical Characteristics of the Glue Line

One-half inch cubes, which included the glue line (Fig. 1C) were taken from each glue study block. The cubes were refluxed until free from air, and stored in a 1:1 solution of glycerine and 50 per cent alcohol. From each cube eight cross-sections approximately 20 microns thick were cut on a sliding microtome, stained in a solution of 1 per cent saffrin, dehydrated by the standard water-alcohol technique, cleared in xylene, and mounted in clarite.

These sections were used to obtain measurements of the exterior glue line, which is indicative of the depth of penetration of the glue into both laminae and of the interior glue line, which may be defined as the thickness of the glue line between the surfaces of the laminae. Photomicrographs of representative glue lines were taken (Fig. 4).

Table 5 lists the results of the glue line measurements. On the basis of the photomicrographs and Table 5, it is possible to hypothesize regarding the effect of wood moisture content on the physical characteristics of a resorcinol glue line.

With the applied pressure essentially constant as it was in this study, it would seem that the thickness of the interior glue lines should remain fairly constant unless other factors were operating. The photomicrograph of the 0 per cent glue line (Fig. 4) and the data in Table 5 show that this is not the case. The interior glue line is more than twice as thick in the 0 per cent group as it is in any other group. Relatively small but significant differences exist among the remaining groups. In general there seems to be a trend of decreasing interior glue line width with increasing moisture content (Fig. 5).

Table 5.—EFFECT OF MOISTURE CONTENT ON GLUE LINE THICKNESS

Moisture content at time of gluing	Number of measurements	Thickness of glue lines	
		Interior	Exterior
Per cent		Microns	Microns
1.10	113	183 ± 5	315 ± 29
4.18	118	50 ± 3	552 ± 38
8.06	127	44 ± 2	554 ± 24
13.79	133	61 ± 3	612 ± 47
21.81	127	36 ± 1	541 ± 29
51.13	129	42 ± 1	540 ± 30

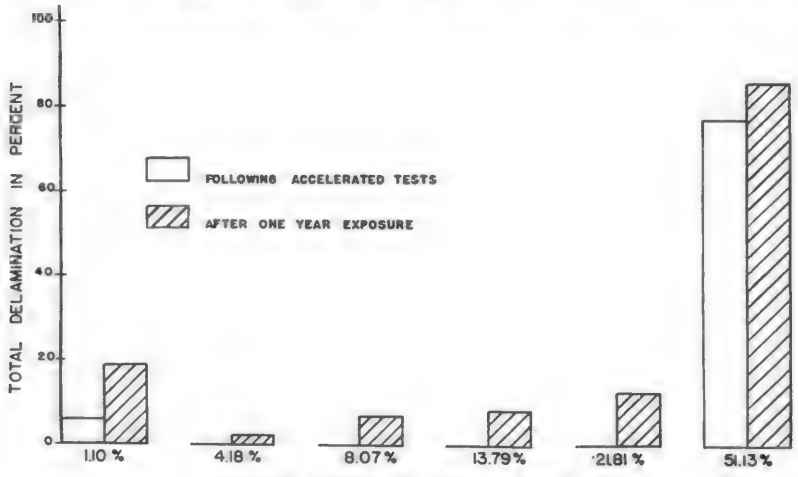

Fig. 3.—Percentage delamination occurring after the accelerated tests compared to that of the same blocks after one year exposure to weather.

The striations appearing in the glue line of the 0 per cent group, Fig. 4, are worthy of comment. Striations or cracks similar to this were noted in resorcinol glue lines by Kitizawa and referred to as crazing.[4] Since the resorcinol adhesive used in this study is considered to be craze resistant, it is believed that they might more accurately be termed solvent migration lines. These striations are believed to be angled according to the extent of plastic flow and this in turn is influenced by such things as catalyst activity, pressure, temperature, and wood moisture content. It was noted that the angle varied with the moisture content of the wood and that relatively few striations were present in the 50 per cent moisture content group. Time did not permit the more exhaustive microscopic study necessary to determine if an exact relationship existed between the angle of the striations and the moisture content of the wood at gluing.

It is generally agreed that it is more difficult to produce a well machined surface with green wood than if the wood is relatively dry. This is well illustrated by the jagged appearance of the wood that was typical of the higher moisture content groups (Fig. 4).

Discussion of Results

From the results of the block shear tests, the delamination tests, and the microscopic study of the glue line, it is apparent that wood moisture content will affect the quality of the glue in a manner other than that brought about through stresses applied as a result of the wood changing moisture content in service. Wood of a low moisture content has the ability to rob the adhesive of its solvents. This reduces the mobility of the glue and hence its plastic flow is not sufficient to develop maximum density and minimum safe thickness. This conjecture is

[4] Kitizawa, G. 1946. A study of adhesives in the glue lines of twenty-two woods of the United States. Tech. Pub. No. 66. New York State College of Forestry at Syracuse University, Syracuse, N. Y.

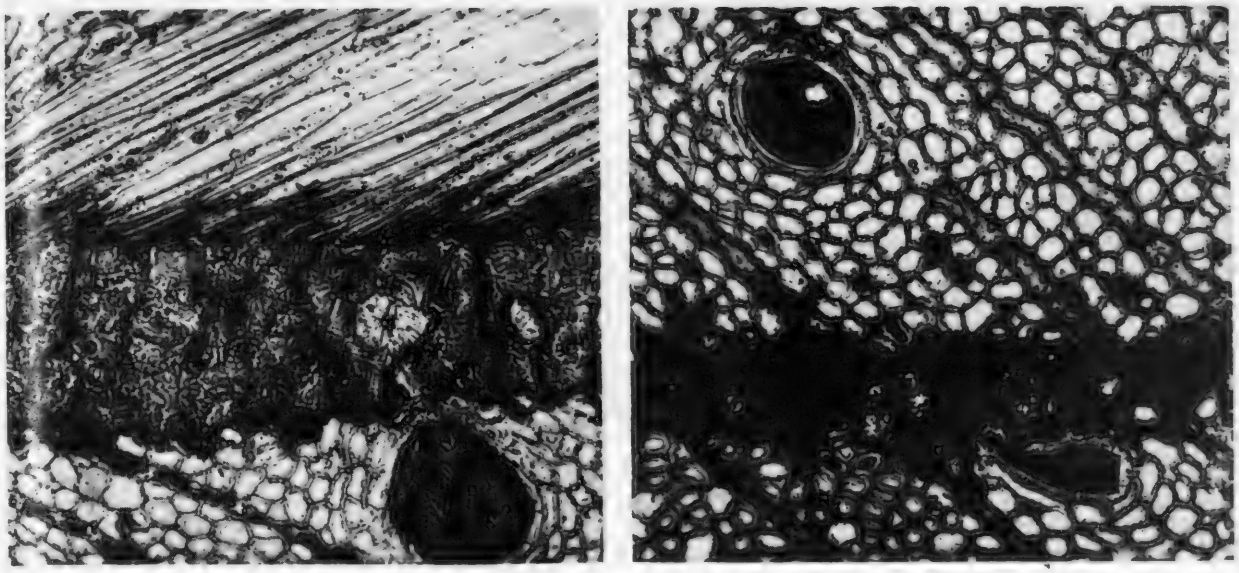

Fig. 4.—Photomicrographs (approx. 200x) of representative glue lines: (left) glued at 1.10 per cent moisture content and (right) glued at 51.13 per cent moisture content.

borne out by the presence of what has been shown to be a relatively thick interior glue line in the 0 per cent moisture content group.

The possible effect of dry wood on the linkage that occurs between the wood and the adhesive should also be noted. It is possible that in very dry wood a portion of the secondary valence bonds of the surface hydroxyl groups are mutually satisfied. This would limit the number of groups available for linkage to the glue molecules and contribute to producing an inferior bond. The difficulties encountered in the secondary gluing of hot pressed plywood have been attributed to a cause such as this. It may also indicate that the linkage of resorcinol to wood is through a water film.

If, on the other hand, the wood to be glued is at a very high moisture content, the excess water will cause the adhesive to migrate rapidly from the glue line resulting in a starved joint. Total migration would not be probable or necessary since a reduction of the solids content of the glue would give similar results. This contention is supported by the fact that the high moisture content group showed low shear strength and wood failure even though the penetration of the glue into the wood was comparable to that of the intermediate moisture content groups. Examination of the specimens tested showed a complete disintegration of the glue to the point where some of the glue lines assumed a chalky consistency and lost their identity. This may have been due to the fact that the glue became immobile while still full of water and air.

Conclusions

On the basis of this study, the following conclusions may be drawn:

(1) Although the gluing of wood at a moisture content other than that at which the material is to be used is not recommended, it is possible to produce satisfactory joints with red oak and a warm-setting resorcinol resin of the type studied at wood moisture contents between 4 and 22 per cent. As used here, a satisfactory joint is defined as one having a dry shear strength of over 1870 psi and a wood failure of better than 75 per cent.

(2) In order to produce a glue joint suitable for exterior service, it is necessary to limit the moisture content of the wood at gluing to between 4 and 14 per cent.

(3) A moisture content that is so high as to give a "wet" gluing surface may alter the consistency of the adhesive to such an extent that the glue loses its identity.

(4) A moisture content that is so low as to give a "dry" gluing surface will alter the flow of the adhesive to such an extent that a form of precuring occurs.

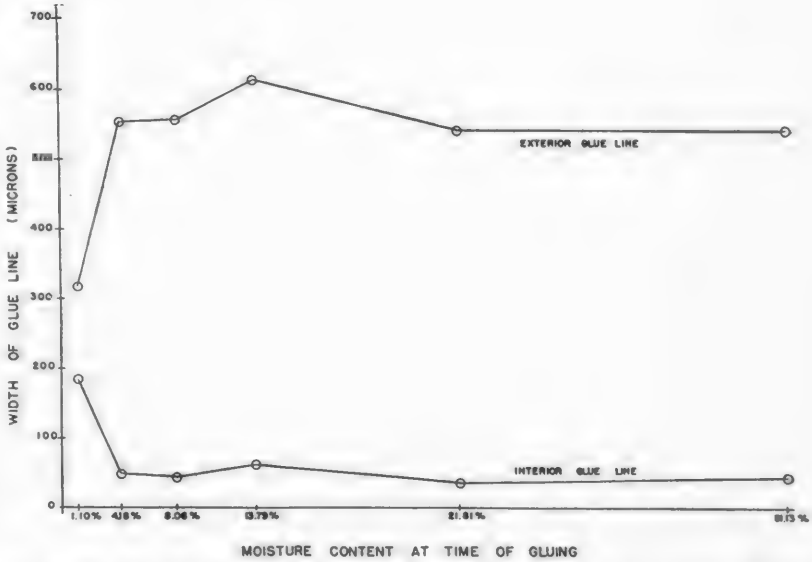

Fig. 5.—The effect of wood moisture content on the width of the exterior and interior glue line.

The Importance of Paperboard as a Forest Product[1]

J. D. MALCOLMSON
Consultant, Robert Gair Co., Inc., Berkeley, Calif.

Development of new uses for paperboard has increased per capita production from 11 pounds in 1900 to 175 pounds in 1955. Corrugated containers are now used in packaging such merchandise as refrigerators, furniture, and other heavy items. The paperboard industry is making inroads in packaging of perishable fruits and vegetables, and research is continually developing additional markets.

PAPERBOARD IS A FOREST PRODUCT which is of considerable importance to this Research Society. This is because of today's large production and the constantly expanding new uses for this material.

The average American probably thinks of this product as "cardboard" or "pasteboard"—terms no longer used in the industry—and undoubtedly would guess that it makes up a very small part of the total paper output. Actually, however, the 1954 production of paperboard exceeded 12 million tons or 50 per cent of all the paper made in this country. It is expected that the usage of paperboard will reach 17 million tons in another five years and 26 million tons in 1980.

About 50 per cent of all paperboard goes into corrugated shipping containers, about 25 per cent into folding shelf cartons, and the balance into setup cartons, cans, drums, book covers, and other uses. Thus over 75 per cent goes directly into packaging, to which would be added bag and wrapping paper. At the annual Packaging Conference in Chicago in April 1955, it was stated that industry this year will spend $10 billion to package its output. Paperboard is undoubtedly the chief tonnage supporter of this program.

The accepted definition of paperboard is any paper product (building boards excepted) which calipers over 0.012 in. An exception is 0.009 in. corrugating medium, which is classed as paperboard.

Paperboard is made by two processes: the Fourdrinier machine for container grades and the cylinder machine for container jute, folding carton stock, and other vat lined miscellaneous boards. Most of the Fourdrinier machines are located in the South, transforming pine pulpwood into liners and corrugating mediums for shipping containers. A recent development there is the production of semi-chemical corrugating medium from hardwoods, which is discussed in more detail later in this paper.

Cylinder Machine: The cylinder machine utilizes waste paper as its chief raw material, strengthened where necessary with new pulp or strong reworked material such as old Kraft corrugated boxes. Cylinder machines are therefore usually located near large centers of population.

The collection, grading, and packing of waste paper is in itself a large industry. Some of it comes from waste baskets but much of this material comes from new paper sources such as envelope factories and newspaper plants. Actually, the Waste Paper Institute recognizes and defines 42 separate grades of waste paper, only three of these being mixed papers.

An analysis of these 42 categories discloses that all were originally wood pulp except for a trace of other fibers such as straw and rag. Thus, the paperboard industry can be correctly considered as one of the important members of the forest products family.

The most important end product of the cylinder machine process is the folding carton. The boards going into today's folding cartons come in dozens of different grades. Some are clay coated on the paper machine; some have grease and moisture resistant qualities; some are laminated or coated with wax, polyethylene or with materials which inhibit corrosion or rancidity. Aluminum foil surfaces are widely used for spectacular appearance and for protection.

Last year the folding carton industry consumed over 2.7 million tons of board and when we add in the other forms of containers, we find that the average American uses 746 paperboard packages a year.

Fourdrinier Kraft: The tremendous growth of the paperboard industry in recent years can be further highlighted by noting that the production of Fourdrinier container Kraft increased from 20,000 tons in 1925 to about 3.5 million tons in 1954. It is expected that this figure will shortly reach 5 million tons and probably be 7 million ten years from now. This is a conservative estimate since the indicated population increase alone would account for this gain without taking into account the development of new uses. Development of new outlets for fibre containers makes greater strides each year.[2]

The above figures mean that on the basis of growth of a half cord per acre per year in the South, the industry is at present cutting and using the growth of 16 million acres per year. However, an adequate supply of pulpwood for the future is assured by scientific forestry, huge programs for planting of seedlings, fire protection, mechanization in the woods, proper cutting and thinning, and the application of forest genetics.

Two other recent conservation developments have gone far toward guaranteeing the future of our southern pulp industry. One of these is the development of cooking methods for increased yield and the other is the invention of semi-chemical pulp for corrugating board which opens up the use of hardwods and other species not suitable for container linerboard.

Refinements in cooking techniques can increase yields from a low of about 45 per cent to a high of nearly 60 per cent. These improvements include more uniformity of chip size, increased use of digester instrumentation, closer laboratory control, and more efficient chemical recovery systems.

[1] Presented at Session V, Packaging, Ninth National Meeting, FPRS, June 21–24, 1955, in Seattle, Wash.

The Author: J. D. Malcolmson, a graduate of U. of Kansas, was the first to conduct research on the corrugated fibre box, while an Industrial Fellow at Mellon Institute from 1918–1922. He was technical adviser for Robert Gair Co., Inc., New York City, from 1922–1953 and has served as an officer and committee member of American Management Assoc., Packaging Institute, Fibre Box Assoc., National Paperboard Assoc., and TAPPI.

[2] Huestis, C. S. The manufacture of kraft linerboard, including control measures. TAPPI 38 (1):115A–118A.

Semi-Chemical Pulp: The growth of semi-chemical corrugating medium during the past few years has been little short of spectacular. In the early days of fibre boxes, the corrugating medium was almost always made from wheat straw. With the advent of Fourdrinier container board in the South came an increasing use of 0.009-inch Kraft for corrugating. Then it was found that while pinewood made the best liners, it was not essential for corrugations whose primary contribution to the box is insulation, cushioning, and rigidity rather than bending quality and light color. Thus was evolved the semi-chemical sheet made from hardwood trees not previously adapted to papermaking.

In 1945 the production of semi-chemical pulp amounted to only about 300,000 tons—almost entirely for corrugating. Now increasing amounts are being used (often bleached) for other papers such as book and printing grades so that by 1953 this production exceeded 1 million tons with an estimated 5 million tons by 1975. Over 50 per cent of today's corrugations are made of semi-chemical as compared with about 16 per cent for strawboard, 13 per cent for "bogus" (fortified chip), and 11 per cent for standard Fourdrinier Kraft.

There are several distinct kinds of semi-chemical pulps, the most important ones using Kraft cooking liquor, acid sulfite liquor, and neutral sulfite liquor. In general, this process obtains high yields from hardwoods by retaining the hemicellulose constituents and therefore might properly be termed "semi-mechanical" pulping. Smaller chips can therefore be used, resulting in reduced cooking time.[3]

In the neutral sulfite cook the chips are often steamed and then cooked with a liquor containing sodium sulfite and sodium bicarbonate or sodium hydroxide. The digester charge is subjected to live steam and the discharged chips may remain in a solid state until subjected to mechanical defiberization. The batch process is still chiefly used but considerable progress is now being made in the use of continuous digesters.

Some liner board is now being produced in the South with a 100 per cent pine Kraft base and a surface layer of Kraft hardwood produced by a secondary head box and provides a smooth even-toned surface for high quality printing.

Increasing Rate of Production

The figures cited indicate that the paperboard industry has been showing an average increase in production of

[3] Semi-chemical Pulping Conference, TAPPI 38 No. 1; 113A–116A.

Fig. 1.—New uses for paperboard include such items as this prize-winning carton for dispensing vitamin tablets. (Photo courtesy of Robert Gair Co., Inc.)

500,000 tons annually for the past ten years. In 1900 per capita production was 11 pounds, in 1940 it was 100 pounds, and today it is 175 pounds. The obvious answer for this growth is the development of new uses for paperboard containers of all styles.

Folding cartons are moving into such fields as hardware, frozen foods, and liquid milk. The latter are made from "special food board," a relative newcomer to the industry which now accounts for over 1 million tons a year. The application of aluminum foil, polyethylene, and special board treatments together with modern printing methods has greatly expanded the use of these paperboard packages. Counter displays of ingenious design serve also as shippers and tempt impulse purchases. As a result, folding cartons are now one of the fastest growing divisions of the packaging industry.

The term "fibre containers" includes both solid fibre and corrugated although at present 98 per cent of these boxes are corrugated. The consumption of corrugated containers has increased nearly tenfold in the past 30 years and at this writing there is every indication that 1955 will break all records.

Corrugated boxes started out as "one man size" containers for fragile merchandise such as Mason jars and other glassware. Soon they were adopted by the canned goods industry, followed by practically all the non-perishable merchandise moving into grocery stores, drug stores, and hardware stores. World War I saw a great increase in their use and World War II developed the "V Box" made of solid and corrugated fiberboard that would withstand several days immersion in water without disintegration and without breaking open. By 1945 the industry was producing 30 million of these boxes per month for the armed forces.

Research and design next turned to more massive merchandise. The first big spectacular success was the corrugated electric refrigerator container. This was followed by juke boxes, radio and TV receivers, ice cream cabinets, and all forms of furniture up to the heaviest of sofas. At the annual exhibit of the Fibre Box Association in Chicago in April 1955, awards were made for such items as nails, cash registers, household water pumps, power lawn mowers, electric signs, water closets, sump pumps, musical organs, concrete forms, electric ranges, filling station pumps, dynamite, and even the kitchen sink—all in corrugated boxes fitted with ingenious and effective inner packing.

Fresh Fruits and Vegetables

There still remained a great unploughed field—perishables. These had always been shipped in crates, hampers, baskets, and other traditional receptacles. Crushed ice, dampness, and melted ice had to be contended with. These obstacles together with merchandising and shipping traditions still exist in most of the field of perishables.

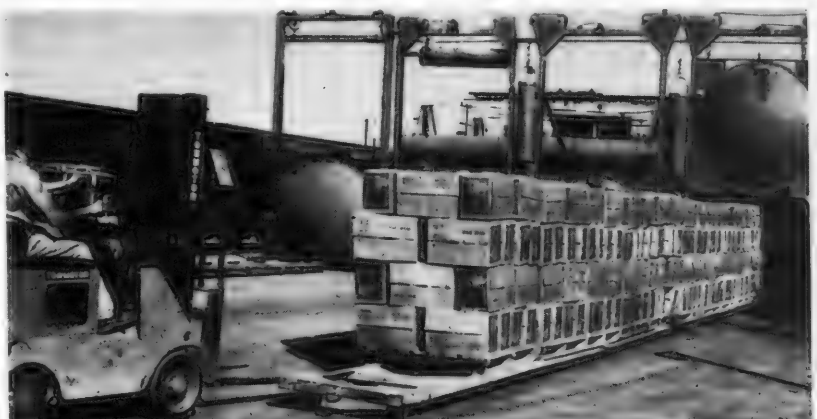

Fig. 2.—Corrugated boxes filled with lemons have tops and bottoms automatically sealed while moving along conveyor. Developed through research, corrugated citrus boxes are now used for shipping 90 per cent of California lemons and are making progress in orange packing field. (Photo courtesy of Sunkist Growers)

Fig. 3.—Development of vacuum cooling systems for refrigerating lettuce has resulted in paperboard containers making huge inroads in this packaging market. Battery of four vacuum coolers, above, are being loaded with lettuce in corrugated boxes. (Photo courtesy of Vacuum Cooling Co.)

Research on the shipment of citrus from Florida and California in corrugated cases had been going on for two generations. Many test shipments continued during that time to study fruit bruising, need of ventilation and refrigeration, costs, and other factors involved in such a revolutionary change of shipping and marketing methods.

Today nearly 90 per cent of all California lemons are moving in corrugated boxes. These are one-half the size of the traditional wooden box and no longer require individual tissue paper wraps nor hand packed layers. The graded lemons are "jumble" packed and the cases automatically glued top and bottom while moving along a conveyor.

Similar progress is being made in carton packing of oranges. Here the percentage in corrugated is much lower at this time but is steadily increasing. Retailers appreciate the flexibility of the half size unit as well as the ease of handling and inspection. The prevention of "blue mold" presented a serious problem which was solved after prolonged research.

The problem of packing lettuce in corrugated was opened up by the invention of the vacuum cooling process. The well known law of thermodynamics was the answer—a gas when compressed gives off heat and when exposed to a vacuum it takes up heat —in this case from a head of lettuce all the way into the heart.

The harvested lettuce is packed into "half crate" corrugated boxes right in the field. Sealing of the empty box is often done with a bottom stitcher mounted on a truck traversing the field being harvested. Lettuce heads are packed into boxes as they are cut and after the top flaps have been stitched down the filled boxes are transported to the cooling plant where large dolly loads are rolled into the vacuum chamber.

The chilled lettuce can then be loaded into refirgerator cars without the use of crushed ice since the corrugated box itself is an excellent insulator. Blocks of ice in the bunkers help keep the temperature down but do not wet the lettuce which cause wilting.

Today, approprimately 90 per cent of all the lettuce grown in California, Arizona, and Texas is going to market in vacuum cooled corrugated containers. A study made by the Department of Agriculture with the Western Growers Association in the 1952–1953 lettuce harvest in certain areas of California and Arizona indicated savings amounted to $80 per car on this vacuum cooled lettuce.

Future Markets

Looking into the future, it can be said that with the exception of lettuce, lemons, and a relatively small part of the orange crop, the rest of the perishable market has hardly been touched by paperboard. Test shipments on cantaloupes, potatoes, and other items are under way but the individual problems to be solved will require a tremendous amount of research.

This research is under way and points up the fact that the paperboard industry is applying modern scientific methods to improve manufacturing practices and to open up new markets. Economy, our most powerful weapon in the past, has already conquered the obvious markets. The growth in per capita consumption of paperboard during the past quarter century can be attributed in large measure to the successful exploitation of basic marketing ideas.

Fortunately, top management in this industry appreciates that future growth must depend on a scientific study of forest conservation, manufacturing methods, and the development of new markets. To these ends, research laboratories are being installed or enlarged and technical and promotional staffs are being augmented at a rapid rate. The results already augur well for a continuing rate of growth in this young but vigorous member of the forest products family.

Dimensional Stabilization of Wood with Carbowaxes[1]

ALFRED J. STAMM

Subject Matter Specialist, Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

The dimensions of small cross sections of wood were stabilized with Carbowaxes to virtually eliminate shrinkage. The stabilization was due to bulking of the fibers—cutting down shrinkage by deposition of materials within the cell walls. Carbowaxes can be readily leached from the wood but can, however, be fixed in the wood by simultaneously treating the wood with an equal weight of water-soluble phenolic resin, then curing the resin.

Introduction

IT HAS BEEN SHOWN that the dimensions of wood can be stabilized by three different means or combinations thereof (6, 7, 12).[3] These are: 1) by reducing the hygroscopicity of the wood so that less water can be taken up, 2) by forming cross links between the interfiber structural units so as to minimize separation of these units and accompanying swelling, and 3) by depositing a bulking agent within the swollen structure so as to reduce shrinkage.

Heating wood to high temperatures for short periods or to moderate temperatures for longer periods of time imparts considerable dimensional stability to wood (8, 10). This was at first believed to be due to the formation of ether cross links by the loss of water of constitution between hydroxyl groups on adjacent cellulose chains (8, 10). It has recently been shown that cross links between the fine structural units are not formed (2). It now appears that the dimensional stabilization is due to the breakdown of the more hygroscopic hemicelluloses and the formation of insoluble polymers from the sugars and furfural formed (2).

Cross linking of polystyrene by polymerization of vinyl benzene with small amounts of divinyl benzene has been shown by Staudinger (17) to give a polymer with greatly reduced swelling. Tarkow and Stamm (18) have shown that cross links analogous to those formed by the divinyl benzene can be formed in wood by reacting it with small amounts of acidified formaldehyde vapor. Unfortunately, this reaction takes place only under such acidic conditions that the strength properties of the wood are badly impaired. Although other cross linking agents that react with wood under less drastic conditions have been sought, none have yet been found.

When wood is treated with solutions of highly water-soluble chemicals, the solution is taken up within the cell walls in concentrations only slightly less than the bulk concentration (11). When the wood is dried, evaporation of water occurs from the microscopically visible capillary structure, thus building up the chemical concentration and promoting further diffusion of the chemical into the cell walls. The wood in drying is thus prevented from shrinking its normal amount as a result of deposition of the chemical within the fibers (4, 5). The amount of dimensional stability that can be attained between the soaked and the oven-dry condition in this way depends upon the solubility of the bulking chemical and the rate at which the wood is subsequently dried. Slow drying promotes more effective diffusion of the chemical into the cell walls.

The reduction of the vapor pressure of water by the chemical also has an effect upon the dimensional stability of wood by bulking. No shrinkage will occur until the prevailing relative humidity has dropped below the relative vapor pressure (in per cent) in equilibrium with the chemical solution within the wood (4). For example, ordinary salt, sodium chloride, when taken up by wood to form a saturated solution reduces the equilibrium relative vapor pressure to 0.75. In this case shrinkage does not occur until the prevailing relative humidity drops below 75 per cent. Because of this, better dimensional stabilization is obtained between two high relative humidities, one of which is above the equilibruim relative vapor pressure of the saturated salt in the wood, than between two low relative humidities.

Dimensional stabilization by bulking was first demonstrated with inorganic salt solutions (4). Salts, however, are not practical dimension stabilizing chemicals. They can be readily leached from the wood, they are corrosive to machining tools and fastenings, and they reduce the relative vapor pressure of water to such a high degree that the wood is always damp at the higher relative humidities. Sugars are better bulking agents than most salts because of their greater solubility in water (5). They reduce the vapor pressure loss, so they have less tendency to make the wood damp. They are noncorrosive, but they do make wood more subject to decay.

Water-insoluble chemicals can also act as bulking agents if they are deposited within the cell wall structure by a replacing process (9) or put into the fibers from an aqueous solution, dried, and then insolubilized by some chemical reaction (13, 14). The first of these is illustrated by replacing the water in swollen wood with Cellosolve (ethylene glycol monoethyl ether) and replacing the Cellosolve with a wax or fatty acid (9). Such bulking agents cannot be leached from wood with water. They have limitations as dimension stabilizing agents, however, because of the difficulty in carrying out the replacement process and the fact that the treated wood cannot be readily glued or normal finishes applied.

That most successful bulking treatment up to the present time has been the treatment of wood with water-soluble phenolic resins, drying and heat curing of the resin within the cell walls of the wood (12, 13). This process has been successfully used in making Impreg—laminated, uncompressed, resin-treated wood (12, 13),

[1] A contributed paper.
[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.
[3] Numbers in parentheses refer to literature cited

The Author: A. J. Stamm, graduate of the California Institute of Technology, taught chemistry at the U. of Wisconsin from 1922–25 while studying for M.S. and Ph.D. degrees in physical chemistry. Since joining the U. S. Forest Products Laboratory in 1925, Dr. Stamm has received international recognition for his work in colloid and physical chemistry. He has conducted product research on capillary structure of wood, electric properties of wood, wood moisture relations, and development of Impreg, Compreg, and Staypak. At present Dr. Stamm is in Australia on a 1-year Fulbright grant, doing research at the Commonwealth Scientific and Industrial Research Organization, Melbourne.

and in making Compreg—laminated resin-treated compressed wood (15). Impreg is finding us in patterns and die models (3); Compreg is used in forming dies, tooling jigs, picker sticks, shuttles, cutlery handles, and clarinets (7, 12).

The highest dimensional stabilization of wood thus far attained has been by acetylation; that is, replacing the hydroxyl groups in the cellulose and lignin of the wood by acetate groups (16). Although this process appears as if the dimensional stabilization is attained by reducing hygroscopicity, this, too, is a bulking process. When the dimensional stabilization obtained by acetylation is compared to that obtained by butyralation, it is found that the volume of acid groups introduced rather than the number of hydroxyl groups replaced determines the stability attained (16).

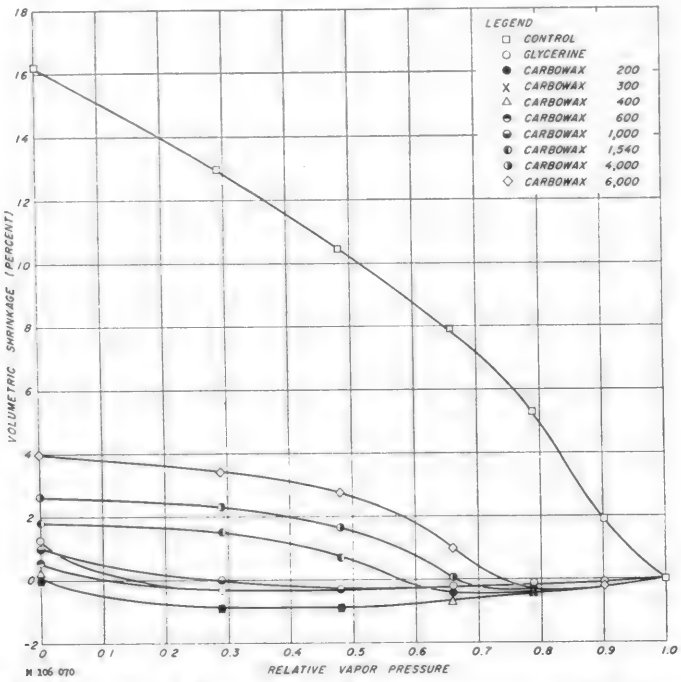

Fig. 1.—The effect of Carbowaxes on the volumetric shrinkage of Sitka spruce cross sections at various relative vapor pressure levels. The specimens were saturated with 25 per cent by weight aqueous solutions of glycerine and each of the Carbowaxes. The average molecular weights of the Carbowaxes are given in the legend.

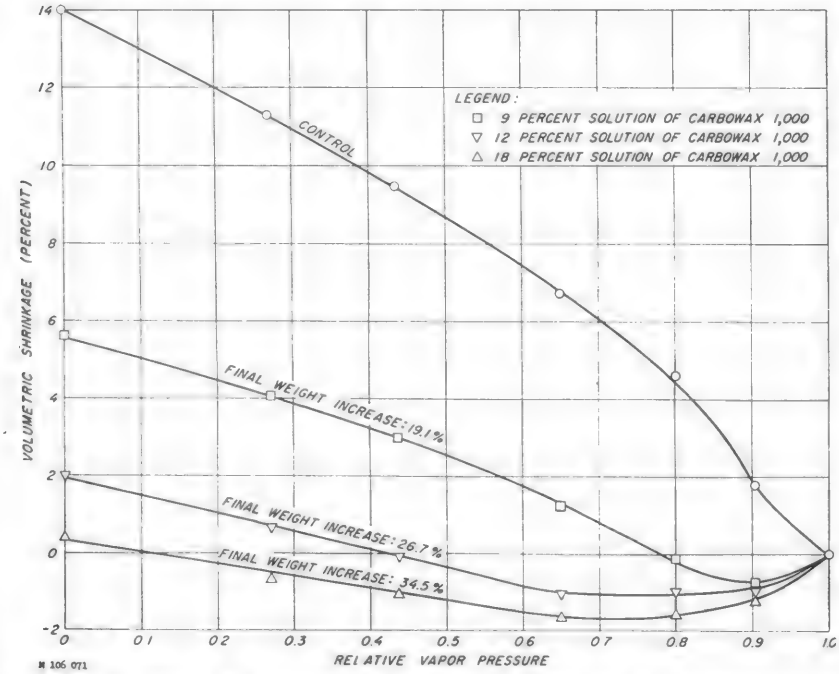

Fig. 2.—Effect of the concentration of Carbowax 1000 solution on the volumetric shrinkage of Sitka spruce cross sections at various relative vapor pressure levels. The specimens were soaked in 9, 12, and 18 per cent solutions of Carbowax 1000. Percentage figures on the curves indicate the weight of Carbowax taken up per unit dry weight of the untreated wood.

Treatment with Carbowaxes

Even though water-soluble bulking agents can be leached from wood, they may find several special practical applications if good dimensional stabilization can be attained. Both the inorganic salts (4) and the sugars (5) previously used have limiting solubilities; hence they will stop diffusing into the cell walls when the water in the cell walls becomes saturated. It appeared desirable to test a series of nonvolatile organic chemicals that are soluble in water in all proportions to determine if greater diffusion into the cell walls than was previously obtained with invert sugar is possible.

A series of Carbowaxes[4] was chosen for these tests. Carbowaxes are polyethylene glycols. They are available in molecular weights ranging from 200 to 6,000. The fractions with molecular weights of 200 through 600 are liquids and are soluble in water in all proportions. Even the Carbowax with a molecular weight of 6,000 is soluble in water to the extent of 50 per cent by weight.

The tests were made on cross sections of Sitka spruce 1/8 inch in the fiber direction and 2.25 inches in the two other directions. The specimens from which they were cut were chosen on the basis of the straightness of the annual rings and were dressed so that the rings were parallel to two opposite faces. Cross sections were used because they furnish the best possible means of matching wood specimens and because of the ease of treating which eliminates all treating variables.

Pairs of oven-dry specimens were weighed and the tangential and radial dimensions measured with a dial gage to one-thousandth of an inch. They were then soaked in water and in 25 per cent by weight aqueous solutions of glycerine and each of the Carbowaxes. To insure saturation, the submerged specimens were put into a vacuum desiccator that was then evacuated; when the vacuum was released, the specimens became completely saturated. The specimens were left submerged over the weekend to attain diffusion equilibrium. They were then blotted, rapidly weighed and measured, and transferred to a humidity room held at 80° F. and 90 per cent

[4] A recent patent by the Upson Company (U. S. 2,629,674) discloses the use of Carbowaxes for stabilizing fiberboards. Their work implies recognition of the impermanence of the treatment in the presence of liquid water. To overcome this, the Upson Company recommends treatment with equal parts of the Carbowax and a thermosetting resin.

relative humidity. Humidities were checked with an electric hygrometer.

The specimens were weighed and measured after 7 days and again after 10 days drying. Differences between the readings for the two times of drying were small. The specimens were transferred to a humidity room held at 80° F. and 79 per cent relative humidity, then successively to humidity rooms at 66 per cent, 48 per cent, and 29 per cent after attaining virtual weight and shrinkage equilibrium in each room. The specimens were then oven-dried, weighed and measured. The weight increase of the specimens due to deposition of Carbowax in the structure averaged about 56 per cent.

The data for the volumetric shrinkage (sum of tangential and radial shrinkage) are plotted in Fig. 1. All of the treatments reduce the shrinkage of the wood to a considerable degree. The poorest reduction between the soaked and the oven-dry condition was to 25 per cent of normal by Carbowax 6000. The dimensional stabilization improved with decreasing molecular weight of the Carbowax to Carbowax 600. Below this value there is little change. The dimensions of the oven-dry specimens treated with Carbowaxes 200 to 600 are virtually the same as the original soaked dimensions. To attain this, water within the cell walls of the swollen specimens must be entirely replaced by Carbowax. This is not surprising since other polar liquids, notably Cellosolve, have been previously shown to completely replace water (9).

Glycerine, the second member of the Carbowax series, gives a somewhat greater shrinkage than the low molecular weight Carbowaxes, presumably because some of it vaporized from the wood in the final ovendrying process.

It is of interest to note that all of the treated specimens swelled slightly in the initial stages of drying. This is due to the fact that wood swells in these concentrated solutions slightly more than in water alone and that diffusion continues into the cell walls as drying progresses. In the case of the Carbowaxes that are soluble in water in all proportions, this diffusion continued down to equilibrium with a relative vapor pressure of about 0.5. With the less-soluble Carbowaxes, diffusion into the cell walls ceased when the solution in the coarse capillary structure became saturated. It thus appears that the inferiority of the higher molecular weight Carbowaxes compared to the lower for dimensional stabilization of wood is due to loss in solubility rather than to molecular size.

Fig. 2 gives similar data for a different set of specimens that were soaked in 18, 12, and 9 per cent solutions of Carbowax 1000 giving final weight increases of 34.5, 26.9 and 19.1 per cent. These specimens were left in the higher humidity rooms for longer periods of time (at least 3 weeks). This accounts for the greater extent of diffusion into the cell walls and for the greater swelling in the early stages of drying.

If the fiber saturation point of the wood is assumed to be 30 per cent and the specific gravity of the Carbowax is 1.125, the maximum volume of Carbowax that could enter the cell wall per gram of wood is 0.307, 0.237, and 0.168 for the three concentrations. These values are 100, 80, and 57 per cent of saturation. From the per cent shrinkage to the oven-dry condition relative to the control, the amount of bulking should be 98, 85, and 60 per cent. These values are near the maximum amount that could be taken up within the cell walls, indicating that diffusion into the cell walls must be quite complete. This is in agreement with the microscopic indication that diffusion of water-soluble phenolic resin into wood below the saturation concentration is so complete that no resin deposit can be detected on the cell walls (12).

Fig. 3 gives isotherms for the desorption of water vapor from the Sitka spruce and from the Carbowax 1000. Also plotted are the observed values for Sitka spruce containing 0.345 gram of Carbowax 1000 per gram of dry wood and the values calculated from the data for the wood and the Carbowax on the basis of the mixture law. The observed moisture contents are somewhat less than the calculated values. The data show that the wood containing Carbowax is more hygroscopic than the untreated wood only above a relative humidity of 80 per cent. Only above 90 per cent relative humidity does the wood feel real damp.

A few attempts were made to fix the Carbowax in the wood by treating with water-soluble phenolic resin. Table 1 shows the effect of the concen-

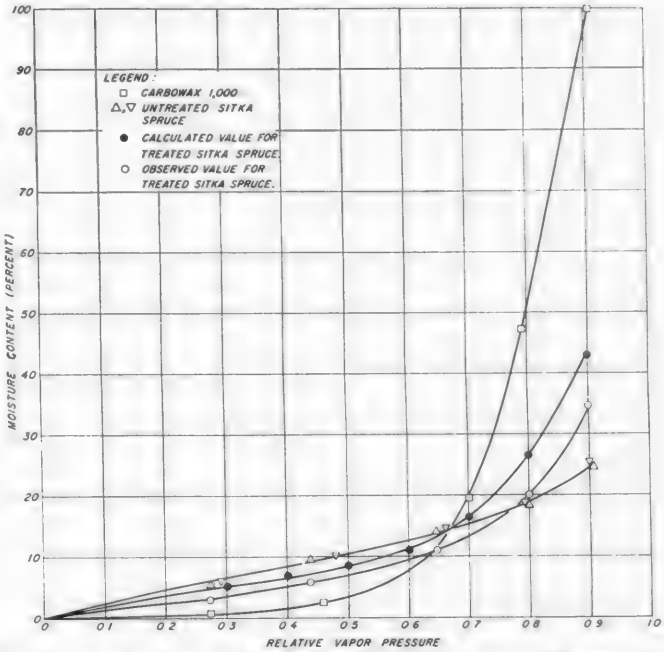

Fig. 3.—Desorption isotherms at 80 F. for Sitka spruce, Carbowax 1000, and Sitka spruce treated to contain 0.345 gram of Carbowax 1000 per gram of dry wood.

Table 1.—EFFECT OF TREATING SITKA SPRUCE CROSS SECTIONS WITH CARBOWAX 600 AND WATER-SOLUBLE PHENOLIC RESIN (BAKELITE 15100) TO FIX THE CARBOWAX

Composition by weight of treating solution	After drying and curing*		After 3 days of leaching†		After 6 days of leaching†	
	Treating‡ solid content Per cent	Antishrink§ efficiency Per cent	Treating‡ solid content Per cent	Antishrink§ efficiency Per cent	Treating‡ solid content Per cent	Antishrink§ efficiency Per cent
30 per cent resin	77.0	78.4	77.2	78.5	77.4	79.7
50 per cent Carbowax 15 per cent resin	139.0	93.0	74.3	82.8	33.6	69.6
16.7 per cent Carbowax 15 per cent resin	70.4	82.0	68.7	62.7	66.2	59.5
8.3 per cent Carbowax 7.5 per cent resin	38.4	68.0	37.6	60.0	37.3	59.6

*Oven-dried and cured for 2 hours at 150° C.
†Leached in water, then dried.
‡Average weight increase after oven-drying over the original untreated oven-dry weight of two specimens.
§Reduction in volumetric shrinkage below that of the control divided by that of the control.

tration of the treating solutions on leachability and dimensional stability.

The specimens treated with phenolic resin alone contained enough resin to completely stabilize the wood if the resin acted the same as the Carbowax. The lower dimensional stabilization is due to loss of water of constitution from the resin in the curing process. Because of this, the optimum antishrink efficiency obtainable is 82 per cent (reduction in volumetric shrinkage below that of the control, divided by that of the control). The antishrink efficiency obtained is thus quite close to the optimum value.

The specimens treated with 50 per cent Carbowax and 15 per cent of phenolic resin gave a high initial antishrink value, 93 per cent. The theoretical optimum value is 96 per cent. Because of the more rapid drying in this case compared to the data of Fig. 1, the attained antishrink efficiency would be expected to be slightly low because of incompleteness of diffusion into the cell walls. These specimens lost about half of their treating solids on the first cycle of leaching and another quarter on the second leaching. If it is assumed that the resin is not leached, practically all of the Carbowax is lost after the second leaching. This assumption seems justified in that the final antishrink efficiency is about what would be expected for the residual solids content being entirely resin (1).

Specimens treated with 16.7 per cent of Carbowax and 15 per cent of resin and those treated with 8.3 per cent of Carbowax and 7.5 per cent of resin gave lower initial antishrink efficiencies, as would be expected. In both of these cases the weight loss due to leaching is quite small. The first leaching caused some loss in antishrink efficiency, but the second leaching caused little. It appears that the resin can fix about its own weight of Carbowax. When more Carbowax is originally present, the Carbowax is not as well fixed initially so that practically all of it can be leached from the wood.

A few tests showed that inorganic salts are not as effectively fixed in wood by phenolic resin as the Carbowaxes. This could be explained on the basis of an insoluble addition compound being formed between Carbowax and phenolic resin. There is still insufficient evidence to prove whether this or physical enveloping is the cause of the fixing of the Carbowax.

Conclusions

Carbowaxes are excellent bulking and dimension stabilizing agents for wood because of their high solubility in water and their nonvolatility. Carbowaxes 200 through 600 are soluble in water in all proportions and as a result can completely replace water in the swollen structure on slow drying to give the wood virtually perfect dimensional stability. Diffusion into the cell walls continues down to an equilibruim relative vapor pressure of 50 per cent for the Carbowaxes that are soluble in water in all proportions. The less effective dimensional stabilization by Carbowaxes 1000 to 6000 is due to their limiting solubility in water.

When the wood contains less Carbowax than that needed to saturate the structure, practically all of the Carbowax diffuses into the cell walls, as indicated by the degree of bulking.

The hygroscopicity of wood containing just sufficient Carbowax to give it virtually complete dimensional stability exceeds that of untreated wood only at equilibruim with a relative vapor pressure of 0.80 or above. It becomes damp only aboue 0.90 relative vapor pressure.

Carbowax can be readily leached from the wood. The treatment should hence not be used for dimensional stabilization of wood to be subsequently subjected to uses under leaching conditions. The Carbowax can, however, be fixed within the structure with an equal weight of phenolic resin.

No data are as yet available on the effect of Carbowax treatment on other properties. It is felt, however, that the strength properties will be similar to those of green wood. The treatment will probably introduce gluing and finishing difficulties.

The treatment at present appears suitable for stabilizing the dimensions of initially water swollen wooden objects that do not require subsequent gluing or painting, that have sufficient strength in the green condition, and that will not be subjected to leaching conditions. It should be possible to stabilize cross sections of trees for display purposes or for table tops to prevent them from developing radial cracks that invariably develop on drying due to the greater tangential than radial shrinkage. It should likewise be suitable for treating of green bolts of wood for art carving. In this case it would not be necessary to carry the replacement to completion before carving. It is conceivable that after a reasonable depth of penetration has been attained by soaking, the bolt could be removed for carving each day and returned to soaking in the solution at night. Data on different size bolts would be needed for several different carving species before the total time of soak prior to air-drying could be determined.

The method should also be suitable for preserving unearthed waterlogged wooden objects of historical value. Frequently such objects, though free from decay, are very refractory because some hydrolysis has occurred. Such objects on drying frequently collapse so badly that they go all to pieces. Soaking in Carbowax solution for some time prior to air-drying should prevent this.

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Impact Modulus of Elasticity in Wood: A Relationship of Impact Values to Static and Dynamic Measurements[1]

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The validity of Young's modulus determined by the standard incremental impact method was investigated by a series of tests on 29 beams of 3 species. The beams were tested non-destructively in static bending, dynamic vibration, and impact, then were broken by the standard method. Calculations of E employing an acceleration formula and a formula based on kinetic energy of the hammer resulted in mean values closer to those determined by static bending than calculations with the standard formula.

Introduction

DESIGN VALUES for wood structures are almost invariably obtained from results of static tests. However, wood in service is commonly subjected to loading produced in comparatively short time intervals. Common instances where wood is subjected to impact loading is in sporting goods, implement handles, and parts of vehicles and boats.

In this country, criteria for estimating the impact behavior of wood, when these are considered, are obtained from results of testing on the Hatt–Turner machine. The test prescribed for this machine specifies incremental loading of the center of a simply supported 2″ x 2″ x 30″ beam. The procedure calls for the dropping of a 50-pound hammer from increasing drop heights until complete failure of the beam is attained. For species in which a drop height of about 60 inches with this hammer is insufficient to break the beam, a 100-pound hammer is used.

The maximum drop height required is considered to be an indication of the ability of the beam in question to absorb applied energy. In tests of materials, this ability to absorb energy is commonly considered to be the fundamental impact strength quantity. This fundamental quantity is most quickly and easily measured by single-drop methods of test, such as are conducted on pendulum-type machines. The utility of the more complicated incremental type test is mainly that methods are available for calculating elastic strength values from records of the deflections produced by the lower drop increments.

A method for calculating Young's Modulus of Elasticity (E) was developed at the U. S. Forest Products Laboratory. It has since been published in texts and reference books among which are *Technologie des Holzes* by Kollmann (11)[2] and *Wood Technology,* Volume 2 by Brown, Panshin, and Forsaith (4).

Tabulated values of modulus of elasticity (E) as calculated from results of drop-hammer type impact tests are rarely found in the literature. In the few publications (1), (5), (6), and (14) in which the writer was able to find values for E so calculated, comparison of the E values from species to species and within species showed seemingly inconsistent variations. Thus, coast type Douglas-fir (*Pseudotsuga menziesii*/Mirb./Franco) in the green condition was reported to have an impact E about 24% higher than the static E for the same material. Air-dry coast type Douglas-fir had an impact E about 66% higher than the static E for the same material. Mountain type Douglas-fir showed impact values which were 7% higher in the green condition. Douglas-fir from Taymount, Scotland, gave an impact E 45% higher than the static E in the green and 31% higher in the seasoned condition. This is a reversal of the situation just previously noted. In Douglas-fir from Taymount, Scotland, the E value for seasoned material was about 8.7% more than for green material; but, for the same species from Argyllshire, Scotland, the increase in E after seasoning was 68.4%.

In comparison with these variable E values, Young's moduli obtained by non-destructive methods of dynamic testing are consistently higher than static values within close percentage limits (9 and 10).

Possible Sources of Error in E Inherent in Test

The wide ranges of impact E values in the published literature and the apparent lack of agreement of these values among species, between species, and on the basis of moisture content may be caused in part by the effect of variability in reaction of the dropped hammer after contact with the beam. Due to the mechanics of the test, the hammer displacement is registered and is assumed to be a direct indication of beam deflection. No allowances are made for any possible out-of-phase relationships between the travel of the hammer and the induced motion in the beam which might exist if the hammer is not in constant contact with the beam up until the instant at which the beam attains its maximum deflection. Likewise, no allowance is made for any idiosyncracies which might obstruct faithful reproduction of hammer travel by the stylus on the record paper of the revolving drum. In order to check the accuracy of the deflection records and also to produce a type of record which could be handled as a transient, it was decided to measure the deflection as a function of the electrical output of a strain gage.

It is assumed in the derivation of the formula for calculating impact E that the elastic deflection curve for impact is the same as for static loading. A possible source of error inherent in this assumption is the greater magnitude of creep under statically applied loads.

Since loads are applied more rapidly in the impact method of test than in static methods, the E values as measured by both types of test are not necessarily the same. In fact, work by Kitazawa has shown that modulus of elasticity as measured by dynamic flex-

[1] Entered in Graduate Division, 1954 Wood and Wood Products Award, sponsored annually by Vance Publishing Corp., Chicago. Based on a thesis submitted in partial fulfillment of requirements for M.S. degree at State University of New York College of Forestry, Syracuse.

The Author: John I. Zerbe received B.S. in wood utilization from Pennsylvania State College, M.S. in wood technology from New York College of Forestry, is candidate for Ph.D. degree from latter college. During summer of 1951, he received NLMA scholarship and obtained 10 weeks' training at Timber Engineering Co.

[2] Numbers in parentheses refer to literature cited.

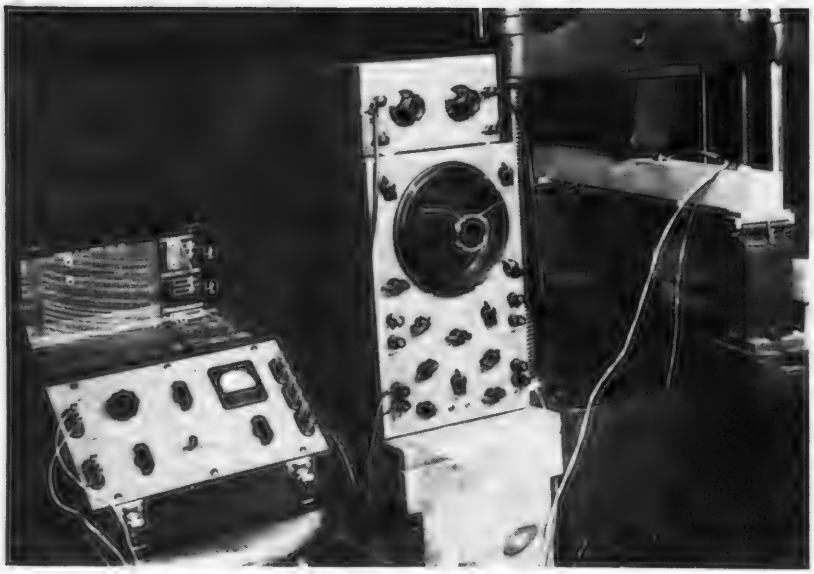

Fig. 1.—Oscilloscope, voltage calibrator, and bridge and amplifier unit used in calibrating the clip gage.

ural test methods, in which beams are vibrated at their fundamental resonant frequencies, is about 10% higher than when measured by static bending. This fundamental resonant frequency for 2″ x 2″ x 30″ beams is usually in the order of about 400 cycles per second and corresponds to a loading time of about 1/1600 second. Poulignier, as quoted by Kollmann, found impact E's about 26% higher in determinations by means of a pendulum type test. Hearmon (8), from analyses of the work of Armstrong, Greenhill, and Thunell, concludes that dynamic methods of test give values for E which are higher than static values by a "few per cent". He has done some supporting experiments to show that from about 3 cycles per second to about 2,000 cycles per second, there is no significant trend for change in E with frequency.

Liska (13), also Brokaw and Foster (3), studied wooden beams in bending, using accelerated loading speeds up to 80 inches per minute, thereby loading to maximum in as little as 0.32 seconds. They found the modulus of elasticity in flexure to be approximately the same for all rates of loading up to the maximum speed employed. Another disadvantage of determining E by the standard method is that it is dependent upon arbitrarily decreasing the slope of the straight line drawn through points relating drop height to squared deflection. The deflection of the beam produced by the weight of the hammer resting on the beam is considered in evaluating E, but this cannot be read directly from the drum record and must also be estimated from the arbitrarily adjusted slope of the proportionality line.

Experimental Procedure

Twenty-nine beams were selected for testing. There were ten specimens of American beech (*Fagus grandifolia* Ehrh.), twelve of red spruce (*Picea rubens Sarg.*), and seven of okoume (*Aucoumea klaineana* Pierre). The beams were brought to an equilibrium moisture content of about 15% prior to testing.

Each of the beams was subjected to a series of tests. Dynamic flexural and longitudinal vibration tests as described by Kitazawa (9) were first conducted on all the beams. Resonant frequencies were estimated to the nearest cycle.

Approximately half of the beams of each of the three species were then chosen to be tested in static bending. The procedure was as outlined in ASTM Standard D 143–52 (2).

All the beams were next subjected to the first of a series of modified impact tests. In this procedure the 100-pound hammer (actual weight 101 pounds) of the testing machine was employed. This hammer was released from drop heights that were limited to magnitudes which would not produce strains greater than the estimated elastic limits of the beams being tested. Furthermore, the deflection measurements were not taken from the stylus on the hammer of the machine. Deflections as a function of the strain in the upper face of the beam were measured by a bent strip of spring steel with electrical resistance strain gages mounted on the faces (two type A–1 SR–4 gages in series on one face with a similar pair on the opposite face). Each of the pairs of gages in series was used in adjacent arms of a modified Wheatstone bridge circuit. The strip with the attached gages will henceforth be referred to as a clip gage. Shallow pilot holes were drilled in the upper face of each beam to take the screws for the clip gage mounts. The gage is shown mounted on a beam in Fig. 1. Since the pilot holes could not be spaced at exactly the same distance on each beam, it was necessary to calibrate statically the clip gage as mounted on each beam.

Calibration of the clip gage was accomplished through use of the equipment illustrated in Fig. 1. In the calibration procedure, a known deflection measured by an Ames dial indicator was produced in the beam by imposing a static load. The signal amplitude for the given deflection as produced by the attached clip gage was fed through an Ellis model BA–1 bridge and amplifier. The unbalance of the gage after strain, from the unstrained null value output, was displayed on a cathode-ray oscilloscope in the form of a chopped, square wave. The amplitude of this square wave was noted and compared to the amplitude of a similar square wave of a known voltage. Actual curves of deflection vs. voltage output were drawn for each of the beams.

When the relationship of beam deflection to change in output of the clip gage had been determined, the individual beams were transferred to the Hatt–Turner machine for the modified impact test. For this testing, drop heights were limited to 2½ inches or less. The hammer was positioned accurately at measured distances above the surface of the beam by means of an adjustable spacer bar. With the clip gage connected to the oscilloscope, the hammer was dropped on the beam. The oscilloscope trace of the impact deflection was recorded on 35 mm photographic film. Then a voltage calibration signal was superimposed on the photograph of the deflection signal. Subsequently, in the course of the work, it was found desirable to also add a time base to each frame. Deflection and time from initiation of impact until maximum deflection could then be measured on the developed photographic image.

Following completion of this first series of modified impact tests, the beams which had not been previously tested statically were subjected to the static bending test as already described.

All the beams were next subjected to the final impact tests. For these tests a hammer weighing 50.7 pounds was used. The regular deflection record for these tests was made on the revolving drum. With the exception of two beams, the deflections for the first three hammer falls were also recorded from the oscilloscope traces of the output from the attached clip gage. In addition, the time required for the hammer

to fall from its original position to the beam surface was measured on a Potter megacycle frequency time-counter. The method used was to place a brass prong on the hammer and connect the prong to the ground terminal of the timer. This prong engaged a starting contact at the beginning of drop and a stop contact when the hammer reached the beam. These contacts were flexible steel leaves connected to the contact start and contact stop of the measuring instrument.

One method employed in analyzing data from the 100-pound hammer impacts was to substitute directly in the standard formula for determining E from impact bending as reported by Brown, Panshin, and Forsaith (4):

$E = \frac{WHL^3}{2bh^3\triangle^2}$ where b = width of beam; h = depth of beam; W = weight of hammer; H = total height of hammer falls; and $\triangle$ = total deflection from no-load position of beam. The value for the ratio $H/\triangle^2$ may be determined by taking the slope of a line through plotted points of H versus $\triangle^2$ for several drop heights.

In order to eliminate errors due to equating work values from impact and static tests, values for E from 100-pound hammer impacts were also calculated by means of a formula derived by Elmendorf (7):

$$F = W_t - (W_t + \frac{17}{35} W_b) \frac{1}{2} \frac{d^2s}{dt^2}$$

where F = force applied by hammer to beam; W_t = weight of hammer; W_b = weight of beam; and $\frac{d^2s}{dt^2}$ = acceleration of beam after initial impact. Average accelerations in tests with the 100-pound hammer for application in the above formula of Elmendorf were calculated by dividing the theoretical velocity of the hammer at the time of contact with the beam by the time for the beam to attain maximum deflection. At the instant of maximum deflection, the beam and hammer were both assumed to be at zero velocity. By plotting the forces (F) for several drops on the same beam with corresponding deflections from the clip gage, a straight-line curve was obtained. The slope of this curve could then be substituted into the formula used for static bending tests and a solution obtained for E.

In the modified impact tests with the 50-pound hammer, values of E were again calculated from slopes of curves of force versus deflection. As was the case previously, force was obtained by calculation from Elmendorf's formula. In this instance however, the deceleration of the beam for calculating force was obtained by using the velocity of the hammer upon striking the beam, as determined from the timed hammer fall through a measured distance, rather than the theoretical value from free fall.

Using the velocity so obtained, as the velocity of the hammer at the instant of contact with the beam, still another value for E from the 50-pound hammer impacts was calculated. This was derived from a consideration of the kinetic energy of the hammer at the instant of contact by equating impact work to static work. The formula used was $E = \frac{Wv^2L^3}{4g\triangle^2bh^3}$ where v = velocity of hammer at time of contact with beam, g = gravitational acceleration, W = weight of hammer; and $\triangle$, b, h, and L represent the previously defined beam dimensions.

Values of E calculated according to the standard method for determination as reported in Brown, Panshin, and Forsaith (6) were obtained from the completed standard impact tests.

Table 1.—RATIOS OF AVERAGE VALUES OF E AS DETERMINED FROM RAPID LOADING TESTS COMPARED TO STATIC VALUES OF E

Type and Conditions of Test	Beech	Okoume	Spruce	All Species
Transverse vibration*	1.122	1.076	1.114	1.108
Longitudinal vibration†	1.232	1.166	1.258	1.227
Modified impact from F/△‡ (100-pound hammer)				
Before static bending	-----	-----	-----	1.163
After static bending	-----	-----	-----	1.158
All tests	---	---	---	1.161
Modified impact from H/△²§ (100-pound hammer)				
Before static bending	-----	-----	-----	1.861
After static bending	-----	-----	-----	1.835
All tests	---	---	---	1.848
Modified impact from v²/△²‖ (50-pound hammer)	0.751	1.020	0.881	0.858
Modified impact from F/△#	---	1.345	0.795	0.895
Standard impact** (50-pound hammer)	3.000	2.793	2.509	2.747

*Forced vibration at fundamental frequencies of beams simply supported at approximate nodal points.
†Rapid shortening and lengthening of beam longitudinally by forcing it to vibrate at its fundamental resonant frequency.
‡Slope of line drawn through plotted points of force as determined from beam deceleration, and deflection measured by clip gage.
§Slope of line drawn through plotted points of total drop height and squared deflection measured by clip gage.
‖Slope of line drawn through plotted points of initial squared hammer velocity from timed drops and squared deflection from clip gage.
#Slope of line drawn through plotted points of force from calculated beam deceleration considering initial hammer velocity and deflection measured by clip gage.
**Impact test by increment drops in Hatt-Turner machine.

Results

Because the purpose of the experiment was to relate the various test methods, ratios of the results from all impact tests are referred to basic values obtained from static bending tests. Averages of such ratios taken from tests on the same beam are shown in Table 1.

Discussion and Analysis of Results

A. Effect of Previous Testing on Stiffness: Kommers (12) found a definite loss in modulus of elasticity following the first loading of a beam in bending to within a few percent of ultimate strength. He explains the loss as "permanent set" produced when the proportional limit was exceeded. Since the proportional limits of the beams used in these tests were apparently not exceeded before the final impact test, it could be assumed that the beams were not subjected to conditions producing a permanent set, and presumably there should have been no change in E between the first and last tests.

Table 1 shows results of the tests made on the beams tested in modified impact before being subjected to the static bending test and those handled in a reverse order. It can be seen that the effect of the order of test method was to give values of E ratio only 0.5% higher by one method of calculation and 2.6% higher by another. Because of the large experimental error involved, no significant difference is shown by these results.

B. Effect of Direct Measurement on Indicated Beam Deflection: Lower values of E ratios were calculated in impact tests by all methods in which deflection was measured by a directly attached clip gage, than were calculated from the standard impact test with the 50-pound hammer in which deflections were recorded by a stylus trace on a drum. The lowered values for E may be partly attributed to the fact that the deflections of the beam indicated by the clip gage are greater than the hammer motion measured by the stylus trace. A comparison of simultaneous clip gage and drum deflections made on the same beam showed clip gage measurements to run consistently higher.

C. Effect of Relationship of Impact Energy to Work in Static Bending Tests: Ratios of E values determined by Elmendorf's acceleration formula from 100-pound hammer tests were closer to the expected values than those of results from calculations employing the standard impact formula. No significant difference was found between the methods in which E values were calculated from beam deceleration and kinetic energy of the hammer at time of contact. Also there was a difference in E values as calculated from potential energy and deceleration. Therefore, it is indicated that not all the potential energy of the suspended hammer is converted to kinetic energy. The loss in energy is probably caused by friction between the hammer and ways of the impact machine.

D. Effect of Friction in the Ways Through Which Hammer Falls: Excessive friction between the falling hammer and the ways of the test machine was indicated by the timed drops of the 50-pound hammer as compared to the theoretical free fall time of the hammer.

The increased time of fall due to friction is directly related to the velocity of the hammer at the time of impact; however, the calculated E varies as the square of this velocity. In consequence, when substitutions are made in the usual formula, a drop requiring twice the theoretical time would result in a calculated E which is too high by a factor of four.

This source of error is apparent in the excessively high E values calculated from the standard impact test results. They average about 179% above static bending values (Table 1). In contrast, the ratios from determinations involving actual impact velocity of the hammer, to static tests, result in average values which are 14.2% and 10.5% lower. This difference is not significantly different from a ratio of 1 as evidenced by the overlap of the fiducial limits involved.

E. Relationship of Rate of Strain to Experimental Values of Modulus of Elasticity: The impact loads from drop heights up to three inches were applied over periods of about 0.008 to 0.010 seconds in the experimental work reported in this paper (deceleration times to maximum deflection). Liska (13) and Brokaw and Foster (3) found no change in E with increased loading speed up to 0.15 inch deflection in approximately 0.09 seconds. Kitazawa (9) found an increase of about 10% over static values employing forced dynamic vibration at fundamental resonant frequencies. The calculated time of loading for this testing was approximately 0.000625 seconds. Therefore, it can be seen from comparisons of loading speed that the change in E, as measured by impact tests, should be less than 10%.

The average ratio of dynamic E, from flexural vibration, to static E for all species in these tests was found to be 1.008 $\pm$ 0.22. This result is consistent with the findings of Kitazawa. Likewise the average ratio of dynamic E, from longitudinal vibration, to static E was found to be 1.227 $\pm$ .029 for all species.

The mean ratio of E values for standard impact to static bending, in these tests, was 2.747 $\pm$ .256 which is obviously very much above the anticipated mean of 1.0 to 1.1. Likewise, the mean ratio for all tests from $H/\triangle^2$, in which the only modification of the standard method was the measurement of total deflection by means of a clip gage was 1.848 $\pm$ 0.213. This is also outside the expected limits.

The methods which depended upon measurement of force from deceleration of the beam, or calculation of the initial velocity of the hammer from timed drops, led to calculated mean ratios which were within the limits of the anticipated values.

Summary

From results of tests conducted on 29 beams of beech, okoume, and red spruce in static bending, dynamic vibration, and impact, the following conclusions were drawn:

1. The mean ratio of E values for standard impact to static bending was 2.747 $\pm$ 0.256. Much of this deviation from the expected mean ratio of 1.0 to 1.1 may be ascribed to friction between the surfaces of the drop hammer and the ways through which it falls.

2. Calculations of E employing an acceleration formula derived by Elmendorf resulted in mean values closer to those determined by static bending than was shown when the same data was used to calculate values with the standard formula.

3. A formula based on kinetic energy of the hammer at point of contact with the beam gave mean values for ratios of impact/static E within 3.7% of those calculated by application of Elmendorf's formula.

4. Beams which were subjected to one static bending test or one series of impacts, provided the stresses were kept below the proportional limit of the beam, showed no significant change in modulus of elasticity.

5. The mean ratio of values for modulus of elasticity was 1.008 $\pm$ 0.0215, when comparing flexural dynamic vibration to static bending. Impact test methods which depended upon measurement of force from beam deceleration, or calculation of hammer velocity, led to calculated mean impact/static E ratios which were not significantly different from those for the dynamic tests already mentioned. Ratios resulting from comparison of E obtained with the standard impact formula to static E, exceeded the range of values based on dynamic testing.

6. When simultaneous records of impact bending on the same beam were made, higher deflections were indicated from an electrical resistance strain gage attached directly to the beam than from the standard stylus record of the motion of the drop hammer.

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Automation in the Board Industry[1]

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Continuous automatic production is essential in maintaining uniform density, thickness, and other physical properties of hardboard and other board products. Use of automatic equipment in board manufacture, from raw material to packaged product, is discussed. Various automatic machines and timing control devices are described.

HARDBOARD AND OTHER board products could not be produced without automatic handling. Continuous automatic production systems are being used in the board industry to as great a degree, if not greater, than any other. The very nature of the processing of the material to make a hardboard product precludes manual handling, and the specifications for the final product could not be met under a "hand-made" label.

Physical effort has always been minimized in hardboard plant installations. The utilization of automatic equipment begins in the raw material yard where trucks, cranes, conveyors, and other mechanical machinery start the log, cordwood, slabs, or other raw material on the journey to eventually become a piece of board.

The economics of a board plant dictate that the wet processing equipment be automatic. The constant flow of raw material through the various pieces of equipment is essential. The flow line from the chipper or hammermill to the attrition mills, screens, washers, consistency regulators, and storage tanks is a continuous automatic system. While the methods may vary as to how this flow is accomplished, it is done basically by automation.

Outside ingredients and additives are introduced into this continuous flow in the form of rosins, sizes, waxes, alum and resins, and this is done in a production manner, using power-driven machines with variable controls.

Wet forming machines or dry felters are probably the ultimate in automatic equipment. At one end of a wet forming machine is a river of fiber, suspended in water, with certain additives dispersed evenly throughout this slurry. Coming out at the other end is a continuous sheet of wet but completely formed mats, ready for pressing. In a dry system, the individual particles are formed into mats on belts, bands, or a series of caul plates, resulting in a continuous sheet ready to be pressed.

Regardless of the type of board being processed, in most instances directly following the felting or forming operation, a saw cuts the continuous sheet, which is then ready for the batching process.

Machinery Design Factors

There seem to be two general directions all board producers follow—one is pressing the product without the use of a supporting means, such as a carrier plate, pan or caul, and the other is using such a carrier, which introduces additional handling problems.

The automation of a caul handling system is, however, usually offset in the first instance by the fact that the product being pressed directly on press plates, or on polished plates attached to the press plates, requires much gentler handling. In many cases, this is a very fragile, dry formed mat which which will not support itself over any distance, either laterally or lengthwise. Careful consideration has to be made in the choice of automation equipment to recognize the fragile characteristics of such a product, and steps must be taken in the machinery design to compensate for this factor.

S2S finished board products, commonly caller re-pressed softboard, pose still another problem in the design of automation equipment. Although this mat has been dried in a regular insulating or softboard dryer and is therefore capable of self-support, such a process involves a very fast cycling operation. For several reasons, the dried pre-forms are usually additionally dried, or pre-heated, just prior to pressing. This means extremely high cycling of the hot press and its surrounding equipment.

A pre-heated, softboard mat is accepted in the handling system in a continuous flow, with little or no gap between one board and the next. Not only does it have to be accumulated automatically in a hot press loader, but it cannot be allowed to remain too long in this loader, or the effect of pre-heating is lost.

This fast cycling requirement is also true in some of the newer Northwest hardboard plants, which are based on the dry or semi-dry process.

Many time saving devices therefore have had to be designed, to cut not only seconds, but fractions of seconds, off the overall handling cycle, in order to equal the production rate of the various processes.

Probably one of the simplest timing arrangements which has been developed is the "alternate loading" of the hot press charger. The hot press charger might be termed the conversion unit between a continuous flowing product at the forming end to a batch operation in the press itself. This means the hot press charger has to accept a continuous flow and accumulate this flow by having the same number or possible a few more openings in the charger than in the hot press. When the proper number of boards have been accumulated, they are simultaneously charged into the press while the previously pressed boards are removed. Alternate hot press loading is an electric control scheme which utilizes both the up and down directions of the charger to fill the decks of the charger, thereby eliminating any false pass which would occur if the charger were loaded in a consecutive manner.

In systems where caul plates, pans, or carrier plates are utilized, automation dictates that these must be handled with the minimum amount of manpower. Therefore, self actuated, circulating, or "merry-go-round" systems have been devised. Here the product is placed, by means of vacuum, or mechanical methods onto the carrier

[1] Presented at Session I, Composition Board, FPRS Tenth National Meeting, June 21–24, 1955, in Seattle, Wash.

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plates or into the pan. Then the plates or pans are accumulated in hot press loaders from which they are simultaneously charged into the press. At the same time, companion units to the chargers, called receivers or unloaders, discharge the plates or pans from the press and, working as a mirror image of the charger, lower the accumulated batch, which is individually removed from the receiver, back into a continuous flow line.

Directly behind the receiver, the finished pre-form is removed from the plate or pan and conveyed in one direction for further processing or remanufacture, whereas the pans or cauls must be returned on the circulating system to their starting point, ready for acceptance of another load.

Such "merry-go-round" or caul circulating systems are basically transport conveyors which actually change the direction of travel of the carrying media at the four corners of the circulating system. Timing techniques have been developed to accomplish this action, and various mechanical means to do this job have been designed.

From the actual pressing operation, automation is further carried into remanufacture. The boards are conveyed, turned over, transported through oil dip tanks, water baths, humidifying chambers, bake ovens, etc., all by completely automatic means.

Machine feeders have been developed, utilizing mechanical as well as air and vacuum means, to feed one board from a pile into saws, sanders, planers, etc., without the necessity of manual handling. At the other end, automatic bunchers, accumulators, and stacking machines take the continuous flow and stack or palletize the finished product for warehousing and shipping.

Many products in the hardboard industry are placed in cartons or wrapped in heavy paper with automatic equipment. In some instances, the board product is bunched into the proper size package and completely wrapped in paper, labeled, and stacked for shipment, utilizing a minimum of manual personnel.

Vacuum pick-up units are used in some board plants in the automation of the cauls or carrier plates. In one instance, a vacuum system is used successfully on finely finished chromium-plated cauls at the build-up and breakdown stations of a processing plant for the decorative laminate industry.

In all automation systems, regardless of the industry, the manpower emphasis is on the electricians and electronic engineers to design and develop the necessary electrical circuits and systems. When the machines are in production, skilled maintenance personnel replace the skilled and unskilled workmen as we know them. This is certainly true in a board plant operation, for the heart of a board plant is the electric controller.

Automatic Controls

Two types of controls are basically used in an automation system. One is the time control system where electric or pneumatic timers which can be pre-set are used for the various movements and actions required in the automation equipment. In a time control system, the forming equipment will produce one blank every so many seconds and the entire system thereafter is based on the amount of time from one blank to the next. The necessity of a foolproof operation, and automation equipment which absolutely cannot make a mistake, is paramount when the time control system is utilized.

"Cascade control" is an automatic control system in which the control units, linked in chain fashion, feed into one another in succession, each regulating the operation of the next in line. It is sometimes referred to as "piggy back" control. Basically, this is a sequence control system where one action takes place, and when completed causes the following subsequent action to commence.

The sequence control system, from an automation standpoint, is by far the safest. Something must happen before the next can start. Tell-tale lights are used to great advantage so that a skilled supervisor can immediately determine whether a failure has taken place and can rectify such failure without injury to equipment, product, or possibly himself.

Hardboard automation, in every instance, requires a complete safety interlock control system, again based on known electrical practices, to eliminate the possibility of non-functioning of the system between one unit and the next, with ensuing damage to the product, machinery, or personal injury.

Conclusions

There is no doubt that the manufacture of hardboard, softboard, and allied products, by the very nature of the raw material as well as the characteristics of the finished product, lends itself perfectly to the use of automation equipment.

An example of automatic machinery accuracy, as compared to human accuracy, is in the forming (either wet or dry) of a mat to produce board. It is possible to form such a mat by hand, but it would be impractical to assume that uniformity could be attained and maintained by hand forming, as compared to a properly designed automatic forming machine. To produce a commercially acceptable product, it is imperative to have uniformity of density, thickness, and other physical properties, not obtainable by hand methods.

Another example is in panel sawing. A well-designed saw will do a better, faster, more accurate, and uniform job than can possibly be done by hand. Therefore, the economic justification does not specifically lie in the saving of man hours required to do the sawing, but in the accuracy, production, and appearance of the board product itself.

Automation has removed much of the back-breaking, manual labor from industrial plants, but at the same time these machines require a growing force of trained engineers, technicians, electricians, supervisors, and maintenance men to keep them in operation.

The objectives of automation are to bring balanced production, uniform and controlled quality, and lowered production costs. Certainly all who are vitally interested in the furtherance of wood utilization recognize the need for these qualities if our industry is to continue and expand.

Discussion

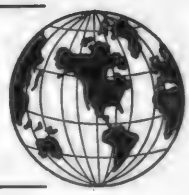
Alec Fisken (Weyerhaeuser Timber Co.): What type of limit switch do you recommend?

Mr. Campbell: Limit switches are a problem. There is no universal limit switch on the market which fits all conditions. One of the main problems, particularly in sequence control systems, is that the limit switch must trip with a positive action and work only once. If the switch is spring loaded, you sometimes get a bounce and it will work twice.

E. M. Williston (Weyerhaeuser Timber Co.): Is there a limit switch on the market that is absolutely dustproof?

Mr. Campbell: There are some limit switches advertised as being in dustproof containers. Under the circumstances of particle or hardboard manufacture, a good ventilating system is required. Wherever you get dust combined with oil or grease, you have a difficult situation to control. Minimizing dust in your limit switches is a matter of good housekeeping as much as anything. Housekeeping is an important factor in any automatic operation. Unless maintained properly, limit switches and other controls will eventually fail to function properly.

Around the World in Forest Products Research and Development



Australia

• The Minister in charge of the Commonwealth Scientific and Industrial Research Organization (Melbourne) has announced to the Australian House of Representatives that experiments had shown that a thin film of cetyl alcohol spread over the surface of water reduced evaporation by 50 percent or more. In the laboratory evaporation has been reduced by 80 percent. The process was simple and cheap and tests which were expected to be completed within 12 months, were very promising. The process could be of outstanding importance in saving Australia's water, particularly in arid areas.

Canada

• It is reported that the Government will finance the building of a $2 million pulp and paper research laboratory to be located near Montreal. The laboratory would be operated by the Pulp and Paper Research Institute of Canada under a 99-year lease. Plans are well advanced, and the project may be completed by the end of 1956.

The aim of the new laboratory would be to help Canada catch up with the Scandinavian countries in pulp and paper research. Although Canada is the world's leading producer and exporter of newsprint, the country is still behind Sweden, for instance, in research.

India

• The Ministry of Commerce and Industry, Government of India, under its schemes for the training of artisans in modern wood-working machinery, has decided to establish four model carpentry wood workshops as well as mobile carpentry shops in the country, attached to the Small Scale Industries Institutes in Delhi, Bombay, Calcutta and Madras.

The scheme for the development of small-scale wood-working industries is meant for only small towns and larger villages where electricity is available.

Rome, Italy

• An international technical conference on insulation board, hardboard and particle board will be held in Geneva, Switzerland next January. It is being called by FAO-United Nations and the Economic Commission for Europe to provide better understanding of the technologic and economic problems involved in manufacture, marketing, and use of these materials.

Some 90 papers will be presented as background to discussions on aspects of the industry which doubled its output in the years 1946–50 and has accelerated since. Attendance will be made up of equipment suppliers, board manufacturers, users, and industrial and technical laboratories throughout the world.

Materials discussed will be those developed in the past 30 years: Insulation board, which in Europe rose from 6,000 to 229,000 metric tons in the period 1930–50; hardboard, which rose from 3,000 to 509,000 tons between 1932–50; particle board, of which 50–60,000 tons were produced in 1950. In 1955 U. S. production was estimated at 75,000 tons.

In 1953 total world production of insulation and hardboard was estimated at 2.5 million tons, equally divided. In 1954 this figure rose to 3 million tons. Further expansion in production of these boards is expected to meet increases in demand for wood products in the coming decade—demands which cannot be met wholly by the sawn lumber industries.

Wayne C. Lewis, U. S. Forest Products Laboratory authority on composition boards and well-known FPRS member, is on the Secretariat for this conference. Last Fall he went to Rome to help arrange the agenda, and will return there this summer to review and prepare summaries and reports of the 90 background papers, many of which have been invited from U. S. and Canadian sources.

Laguna, Philippines

• Past director of the U. S. Forest Products Laboratory and currently technical advisor to the Bureau of Forestry, Republic of the Philippines, George M. Hunt reports from the new Forest Product Laboratory:

"We will have an article about this Laboratory to contribute some day but have been holding back until we get better equipped and established. It will be some months yet before we reach that position.

Our work moves ahead slowly but we can see that we are making progress. Much new equipment is coming in now and it is being installed and put to use as rapidly as possible."

Scanning World-Wide Forest Products Publications

Svensk Papperstidning, No. 20, 1955. The Utilization of Bark: II. Investigation of the Stiasny Reaction for the Precipitation of Polyphenols in Pine Bark Extractives (In English) Arne Wissing, Swedish Forest Products Laboratory.

The utilization of extractives from waste pine bark has gained special significance. As known, these extractives contain tannin of the phlobatannin type and this kind of tannin is a potential source of raw material for adhesives.

The first step was to find a suitable method for analysis of the extracts. Also tested were different ways for the refining and concentration of the extracts. It was found valuable to test the relation between the pH-value of the reaction mixture and the result of the analysis, particularly in cases of low tannin concentration. The Stiasny reaction, used for quantitative determination of the fractions of tanning extracts, being able to form reaction products with formaldehyde gives comparable results only when the reaction is carried out at the same concentration of tanning material and within a narrow range of the pH-value.

Research Bulletin of College Experimental Forests, Hokkaido University, Sapporo, Japan. Vol. XVII, No. 2. Carbonization of Wood by Dehydrating Agent. Part I: Preparation and Decolorizing Power of Hydrated Active Charcoal (H-A Charcoal) from Wood. (In English) Michio Hanzawa and Seiichi Satonska.

Recorded were some solutions on the preparation and adsorptive power of hydrated active charcoal made from wood by dehydration and carbonization with sulphuric acid at a low temperature. Charcoal was made from the sawdust of fir, spruce, basswood, and oak. It was found that hardwood is superior to softwood for the preparation of H-A charcoal. Ash content of the charcoals made from softwoods was ca. 0.1–0.2 per cent, from basswood ca. 0.65 per cent, and oak ca. 0.3 per cent. The yield of charcoal made from brown rotted wood was high, due to high lignin content.

Abstracts From Current World Literature

Chemical Utilization

Merewether, J. W. T. Lignin XII. The isolation of lignin by alcoholysis in the absence of air. *Holzforschung, Berlin* 8 (4), 1954 (116–23).

[Cf. *For. Abstr.* 16 (No. 926).] Lignins obtained by alcoholysis with ethanol and methanol in the absence of air oxygen differ from each other and from products obtained after exposure of these lignins to air, in the number of methoxyl and hydroxyl groups. [For. Abs. V. 16, No. 3]

Schubert, W. J. Investigations on lignin and lignification. XIV. *Holz Roh- u. Werkstoff* 12 (10), 1954 (373–7).

A review of recent papers (including the author's). The sequence cellulose—glucose—ethanol—acetic acid—oxalic acid is established for the enzymatic decomposition of cellulose. Lignins obtained from different hardwoods and softwoods, and bagasse, by decomposing the cellulosic portion with brown-rot fungi, have been found to be chemically identical with each other and with 'native' lignin, while differing from 'chemical' lignins. The suggested explanation of the lignification process in plants is as follows: the carbohydrates in the cell are transformed enzymatically (via two-carbon-atom units) into oxyphenylpropane elements which can become guiacyl elements by methoxylation; these two aromatic structural elements can yield lignin by way of repeated condensation. [For. Abs. V. 16, No. 4]

Charcoal production and uses. *Bull. Ntheast. Wood Utliiz. Coun.* No. 37, 1952. pp. 101.

Contains the following articles: The physical and chemical properties of commercial charcoals in relation to industrial use *(C. A. Stokes* and *H. Friedenstein);* Small rectangular charcoal kilns *(H. W. Hiscock);* Charcoal production in steel drums *(H. I. Baldwin);* The continuous carbonization of wood: Sific process *(A. Lambiotte);* History and present status of the industry; continuous carbonization, the Mellman retort *(D. F. Othmer);* Beehive kiln operation *(D. F. Othmer);* Domestic uses and distribution *(C. K. Richardson);* Industrial uses *(S. P. Kelly);* Briquetting of charcoal *(R. S. Aries);* and Active carbon *(J. W. Hassler).* [For. Abs. V. 16, No. 3]

Wood Bending

W. C. Stevens and N. Turner. A new type of steaming retort for wood-bending purposes. *Wood,* Vol. 20 No. 1, January 1955, pp. 10–12.

A new method of steaming wood has been evolved to overcome the usual tendency to 'snake', especially when a straight portion is required at each end of a 'hairpin' bend as in the hoop for a Windsor Chair. A retort is arranged to steam only that part of the section which has to be bent, so leaving the stiffness of the remainder unchanged. The retort consists chiefly of an open-ended box, constructed to accommodate a predetermined number of components. Normal steaming periods of about 45 min. per inch of thickness have been used.

An alternative localized heating technique was investigated and proved satisfactory under certain conditions. The part to be bent is heated in a radio-frequency field to a temperature of 100° C. and the moisture it contains is converted into steam. Using this technique excellent bends (Windsor bows) have been made with green beech 4 ft. 2¼ in. x 1⅛ in. x 1⅛ in. by applying a power concentration of about 24 watts per cu. in. for 6 min. [F. D. C. Tech. Bul. V. 5, No. 26]

Properties

M. McCoy–Hill. Timbers of Tanganyika. *Timber Technology,* Vol. 63, No. 2187, January 1955, p. 20.

Mkaraka (Pteleopsis myrtifolia) is a reddish-brown timber which the author considers would be suitable for some items of furniture. It has a fine dense texture, a grain which tends to be wild, and a density of 35–50 lb per cu ft air dry. The timber air seasons slowly with a tendency to surface and end checking which makes end coating essential. It is hard and stiff, but works fairly easily and a fine finish can be obtained. [F. D. C. Tech. Bul. V. 5, No. 27]

Dadswell, H. E., and Wardrop, A. B. The structure and properties of tension wood. *Holzforschung* 9, no. 4: 97–104 (1955).

Tension wood (I) is discussed with special reference to cell-wall organization and lignification. In three different types of (I), the fine structure of the so-called "gelatinous layer" (II) was studied by means of the electron microscope and by x-ray techniques. (I) and normal wood could be distinguished by using safranine followed by a light green stain; unlignified tissues stain green and lignified portions stain red. (II) was shown to be highly crystalline and gave very sharp x-ray diagrams. Lack of lignification has been suggested as the first stage of (I) formation. Microscopic compression failures in (I) are common; their possible causes are outlined. Such properties of (I) as grain "wooliness," high longitudinal shrinkage, and collapse, and the association of these with features of cell-wall organization and degree of lignification are discussed. [Bul. Pap. Chem. V. 26, No. 1]

World timbers: volume 3. Timber Development Association, 1955, 128 pp., *6s 6d*

This volume of 'World timbers' covers 50 timbers from various parts of the world, most of which are on the market at the present time. It gives botanical names and common names, distribution of the species, description of the tree and timber, seasoning, strength, durability, working qualities, uses and supplies. An alphabetical list of all botanical and common names is included at the end of the book. [F. D. C. Tech. Bul. V. 5, No. 28]

Finishing

Liiri, O. The abrasion resistance of wood and wood finishes tested with the 'Taber' abraser. *Pap. ja Puu* 37 (4*a*), 1955 (131–7).

The electrically-powered Taber abraser (illustrated,) of the American Taber Instrument Corporation, was used at the State Institute of Technical Research, Helsinki, on untreated Finnish Scots pine, Norway spruce, birch, hardboard, and plywood, and on some wood finishes. The purpose of the test was to determine the efficacy of the abraser for testing abrasion resistance and to determine some wearing properties of the test materials. The most important results are given in tables and figures with English legends. Sp. gr. greatly affects the resistance of untreated wood, loss in weight, and even more markedly loss in volume, decreasing with increasing sp. gr. Loss in weight, particularly from the transverse surface, was much more rapid for pine and birch when the surface had been cut by circular saw than when it had been planed or sanded. Other results show the effect on loss in weight of the duration of the test, and the loss in weight of different classes of hardboard and of synthetic finish: cellulose lacquer, varnish and enamel paint; the last two had completely worn through after 1000 cycles. The abraser proved very suitable for the purpose and could also be used, with some reservations, to test flooring materials, although its action does not fully correspond to service wear in floors. [For. Abs. V. 16, No. 4]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiber board and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

FORESTRY ABSTRACTS, published quarterly by Commonwealth Agricultural Bureaux, Farnham Royal, Slough, England, subscription price $8.40 per year. The abstracts are prepared by the Commonwealth Forestry Bureau, Oxford, England, and include a Forest Products and Utilization section. This section contains over 1,500 titles and abstracts per year from literature in some 30 languages, covers all aspects of forest utilization.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

Abstracts of Papers, FPRS Tenth National Meeting

Here's Your Preview of Papers to Be Presented at National Meeting in Asheville, June 4–7

Session VI—Keeping Abreast in Wood Gluing

HOW LONG WILL IT LAST—A STUDY OF GLUE LINE DURABILITY. C. C. Booth and J. W. Maxwell, Chemical Div., The Borden Co., New York, N. Y.

Summarizes extensive tests conducted over a number of years by an adhesive manufacturer on the durability of various types of wood glues. Included are actual outdoor fence test observations for 10 years on panels bonded with phenol, resorcinol, and urea-formaldehyde resins. The constructions evaluated are comprised of different thicknesses of yellow birch, yellow poplar, sweet gum, and Douglas-fir veneers bonded under various conditions. Another test series covers the endurance of urea-formaldehyde bonded panels subjected to indirect exposure for periods up to 16 years.

Comparative results are also cited on short-term controlled tests of urea and phenol bonded specimens subjected to conditions of high temperature and moderate humidity.

The superiority of phenol and resorcinol adhesives is clearly established for severe service conditions. Reasonably long endurance can be expected with urea resins when not subjected to direct exposure to the elements. Short-term durability tests employed appear to be a reliable means of predicting adhesive performance with reference to serviceability.

Session VII—Improved Techniques for Wood Drying

CONCEPT OF MOISTURE MOVEMENT IN VENEER BROADENED BY DIFFUSION CALCULATIONS. W. K. Loughborough, Consultant, Winter Haven, Fla.

The process of drying wet solids which is described by Sherwood, Fisher, Kollmann, Norris, and others is examined with reference to wood in general and to veneer in particular. This study was made to test the validity of the premise that the hygroscopic potential that induces the movement of water in other items of wood also induces the flow of moisture in sheets of thin veneer. Several typical veneer-moisture time curves were analyzed with the aid of Newman's diffusion and surface emission equations and his tables of values.

In drying 1/16-inch yellow birch in a constant relative humidity of 75, 60, and 30 per cent, respectively, and a common dry bulb temperature of 200° F., it was discovered that k, the moisture lost per minute when the moisture gradient is 1 per cent per inch in the direction of flow, was identical for each of the three runs. Analyses of the data confirmed Newman's insistence that M, the surface resistance to the escape of vapor into the drying atmosphere, and ha, the nondimensional ratio of M/k, are essential to the proper description of a drying process. Moreover, it was shown that when the k value for one relative humidity is known, the k values for all relative humidities are known, provided all factors except relative humidity are common. The moisture time curves of green sweetgum sapgum which introduced the variable of thickness resulted in a single value of k.

Thus, where infinite slabs are involved, with everything else equal, the drying times are proportional to the slope of the moisture gradient in the direction of flow and inversely as the square of the drying thickness. In actual practice, however, in a given drying atmosphere, an item of veneer may dry very differently as far as rate is concerned, depending on ha, a factor which depends upon the rate of air movement.

Session VIII—Chemicals from Lignin, Hemicellulose, and Other By-Products

THE SEPARATION AND UTILIZATION OF HARDWOOD HEMICELLULOSES. J. F. Harris, J. F. Saeman, and E. G. Locke, U. S. Forest Products Laboratory, Madison, Wis.

The importance of xylan in the chemical utilization of hardwoods and the possibilities for the efficient removal and utilization of xylose are discussed. Separation can be effected by organic solvents or acid hydrolysis. Recently collected data on the removal of hemicellulose from oak by acid hydrolysis are presented to illustrate the yields and solution compositions that might be obtained. The utilization of potential pentose-rich hydrolyzates is reviewed and some process data for furfural production are presented with an economic discussion. This review of the subject elucidates the potential usefulness of the hardwood hemicellulose fraction and points the direction for future research.

Session IX—Wood Machining

GREATER UTILIZATION OF MATERIAL OBTAINED FROM NEW MACHINE. W. K. Murphey, Ohio Agricultural Experiment Station, Wooster, Ohio; and G. L. Schneider, Lexington, Ohio.

A machine has been developed which slices wood, without loss, into material suitable for use in rough products or which may be planed to finish sizes without any more loss of material than ordinarily occurs when sawn blanks are planed. The wood is sliced by a series of round knives mounted on mandrels and spaced by discs which are as wide as the desired lumber thickness. Two of these roller assemblies constitute a roller set which cuts the upper and lower surface of the wood and feeds the wood into the next pair of rollers.

The knives of one mandrel slice the wood to a depth of one-quarter inch; thus two sets of rollers are needed to slice one-inch lumber. Thicker lumber may be sliced by the addition of roller sets.

To prevent cleavage ahead of the knives, a set of pressure plates are placed on the mandrel and spaced the same width as the lumber being remanufactured; thus the wood to be machined must be of a uniform size. Although the knife action compresses the wood in the vicinity of the cut, this compressed material is removed in the planing process.

Session XI—Composition Boards—What the User Wants

INSULATING FIBERBOARD ROOF DECK. Paul D. Close, Simpson Logging Co., Shelton, Wash.

The insulating fiberboard roof deck is one of the most recent products to be developed using insulating board made from wood or other fibers as the basic material. This product combines the roof deck, thermal insulation, ceiling finish, and in some instances the acoustical material.

The standard size is 2 x 8 feet and the thicknesses are 1½", 2", and 3". The long edges have a tongue and groove joint and the short edges, which meet over a beam, are square. Vapor barrier types of the product are available for use where the normal January temperature is below 40° F. In some cases, the 1½" thickness is not available in the vapor barrier type. The lower surface which becomes the ceiling when the roof deck is installed has a white paint finish applied at the factory. Some manufacturers are also supplying an acoustical type roof deck with drilled perforations in the lower face.

Structural and other tests indicate this product has ample strength for ordinary requirements when used on the proper centers which are 24" for the 1½" thickness, 32" for the 2" thickness, and 48" for the 3" thickness. These tests include uniform and concentrated load, impact, continuous load or sag, and accelerated aging tests.

This product is intended for open beam construction and is particularly adapted to modern ranch-type residences. However, it is also suitable for and has been used on many other types of buildings including schools, churches, office buildings, factories, and warehouses.

This product was introduced in California where the non-vapor barrier type is used but its use has spread to all other parts of the U. S. As the roof generally comprises the largest area of a building and since multiple thicknesses of insulating board are required to make this product, the potential footage of material for this roof deck is tremendous. Surveys have indicated a constantly increasing market for this product.

Session XIV—Improved Plywood Products Through Technology

INVESTIGATING ROTARY VENEER CUTTING WITH THE AID OF A TENSION TEST. Eero Kivimaa, State Institute for Technical Research, Helsinki, Finland.

This report describes the method used in making investigations of rotary veneer cutting at the State Institute for Technical Research in Finland. In these investigations, the tensile strength of the veneer perpendicular to the grain, which is determined by means of a tension test, has been adopted as the standard of veneer quality. Additional tests along similar lines, performed at the U. S. Forest Products Laboratory are described. By using the tension test to evaluate the quality of veneer, a clearer picture of the influence of nosebar pressure on the quality of lathe-cut veneer has been obtained.

FPRS News-Digest, Continued

NEW PRODUCTS—LITERATURE

Fork Lift Truck

Ottawa Steel Division of the L. A. Young Spring and Wire Corp., Ottawa, Kans., has introduced the Tracto-Lift, designed for outdoor materials handling. The Tracto-Lift is available

in models of 5,000, 6,000 and 7,000 pound capacities. Features included as standard equipment are: shuttle gear transmission with control lever on steering column, providing six speeds forward and six speeds reverse; power steering; and an hour meter.

The unit is available with pallet forks of various lengths as well as tine forks. A side shifter load carriage for use with either pallet or tine forks is optional equipment. The standard load carriage is 48 inches wide, but a 64-inch carriage also is available.

Tool Catalog

The full range of tools distributed by Price and Rutzeback, 22150 Meekland Ave., Hayward, Calif., is described in their new catalog, MC-902. The literature illustrates a wide variety of carbide-tipped tools and details all sizes of the new chromium-processed "Tuff-Tooth" saw blades. Other tools in the Parco line, machine and portable, are also included.

Porcelain–Plywood Panel

Introduction of a new porcelain-faced plywood panel, adaptable for industrial and home uses, exterior and interior, has been announced by U. S. Plywood Corp., New York. All panels come 36 by 96 inches, 5/16-inch thick, and are available in nine colors.

Called Porc-Lin-Ply, the sheet has a 3-gauge, .012-inch steel face treated with two coats of porcelain fused under 1600° heat. The core is of ¼-inch exterior grade plywood. A metal backing gives balance to the panel, which weighs 1.75 pounds per square foot.

Reported to be weatherproof, the panel may be installed with mouldings and caulking which may be purchased with the panel. The new material is also said to be resistant to odors, ordinary acids, oil, grease, smoke, and solvents.

Log Marker

A new log marking paint and the Nel-Spot Paint Hammer have been developed by the Nelson Co., Iron Mountain, Mich. The hammer uses a pint can of paint clamped like a hammerhead in a bracket at the end of an

18-inch wooden handle. A porous applicator sealed into the neck of the paint can emits sufficient paint to make a mark as the device is tapped against the end of a log.

The tapping angle may be controlled by adjustment of a wing nut on the bracket which holds the paint can. The paint requires no stirring because of special additives which prevent settling. It is reported that the hammer produces 20,000 marks to a gallon of paint.

Sawmill Conversion Kits

Expansion of its line of conversion kits, designed to aid sawmill operators in mechanizing existing equipment, has been announced by Mater Machine Works, Corvallis, Ore. The kits are manufactured in a variety of sizes to accommodate small and large mills. They are completely packaged with blueprints, ready to install over a weekend shutdown.

The air-operated conversion kits now include five different types of air dog conversion kits; two types of hook dog conversion kits; taper conversion kits, to put tapers on knees; flipper conversion kits; setworks conversion kits, to convert from one-man-on-carriage to automatic operation; and deck and log turning conversion kits, to mechanize existing decks and turning equipment.

SEE US IN BOOTHS 82 & 85 AT ASHEVILLE, JUNE 4–7

MODEL M
PUSH BUTTON—AIR DRIVE
Dependable pneumatic Spotnailer drives heavy gauge staples or pins in lengths up to 1¼ inches at high speed.
MODEL B
STANDARD HEAVY DUTY—MALLET DRIVE
For driving longer heavy-gauge staples and pins.
Magazine holds up to 200 fasteners.
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For Faster - Lower Cost
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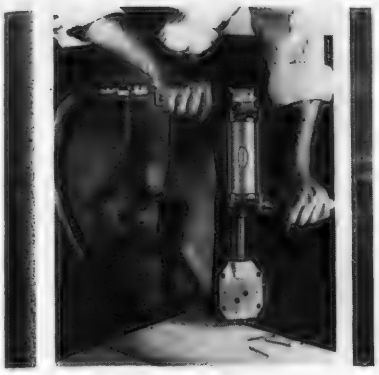
and PINNING!
NAIL Pittsburgh Seal, Interior Panels, Cabinets, Insulation Board, Floors, Roof Trusses, Heat Ducts, etc.
MODEL AF
STANDARD MALLET DRIVE SPOTNAILERS
Extremely dependable, medium duty machine widely used for fastening millwork, floor underlayment, etc.
MODEL P
HIGH VELOCITY AIR DRIVE
Well balanced tool speeds fastening operations with a minimum of operator fatigue.
Your Spotnail Man can help you solve tough fastening problems. Call him now.
SPOTNAILS, INC. Evanston 4, Ill.



Nail Remover

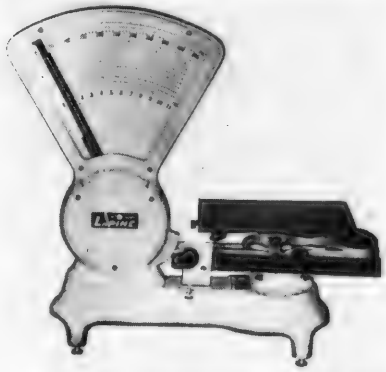
An automatic nail puller has been added to the line of "Controlled-Air-Power" work devices marketed by the Bellows Co., Akron, O., which has secured sales rights from the W. D. Allen Co., Chicago, developers of the unit.

The tool is built around a Bellows Air Motor and the air connection is made with a 12-foot length of ¼-inch hose supplied with the unit. Two models are available, one for pulling common nails in the 3- to 7-penny range and one for 6- to 10-penny sizes. Each model weighs 10 pounds.

It is reported that crates and boxes may be dismantled and temporary building forms salvaged without lumber spoilage. Nails are undamaged as pull is perpendicular and heads are left intact since the nail's shaft is gripped.

Laboratory Scale

Weight can be read rapidly to one gram on a new automatic self-balancing scale recently added to the Arthur S. LaPine & Co. line of balances. High-speed weighing is furthered by an adjustable hydraulic damper which brings the indicator to rest in 2½ oscillations.



The dial reads to 500 grams and total capacity of 5,000 grams is attained with a poise sliding on a notched beam. Scale sensitivity is readable in both metric and avoirdupois units for laboratory use.

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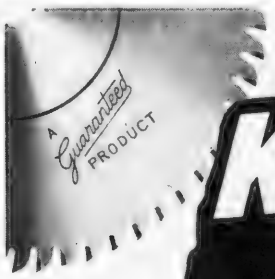

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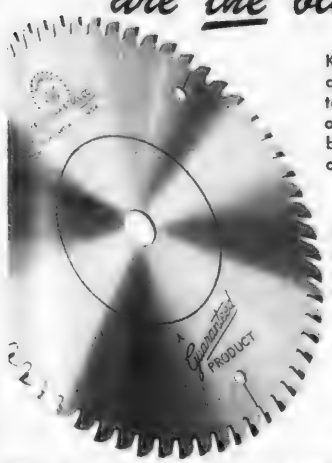

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FPRS News-Digest, Continued

NEW PUBLICATIONS

Rotary Cutting of Curly Yellow Birch. O. Feihl, Forest Products Laboratories of Canada, Ottawa, Ont. Reprint from Canadian Woodworker. Reviews trials in a commercial plywood mill showing that a precise technique developed in the laboratory can be applied to commercial veneer cutting operations.

Fractionation and Identification of the Hemicellulose Components of Black Spruce. L. P. Clermont, Forest Products Laboratories of Canada, Ottawa, Ont. Reprinted from Pulp Paper Mag., Canada. Reports on a detailed investigation into the chemical composition of the hemicellulose fractions of black spruce and an attempt to determine the molecular complexity of the fractions by making use of the shape factor k^1 obtained from Huggin's equation.

Sap Stain and Mould Prevention on British Columbia Softwoods. H. W. Eades, Forest Products Laboratories of Canada, Vancouver, B. C. Bulletin 116, 1956. Describes a series of investigations undertaken by the Vancouver Laboratory to determine the effectiveness of the various chemicals in commercial use for stain prevention. The studies included the more important softwood lumber species of British Columbia and were made on lumber and box shooks.

What You Should Know About Expendable Pallets. National Wooden Pallet Manufacturers Assn., 609 Barr Building, Washington 6, D. C. Includes data on types of expendable pallets, construction standards for pallet parts and fastenings, allowable tolerances, provides an application rule for use of expendable pallets, lists definitions and terms.

Publications on Forest Genetics. Compiled by Keith W. Dorman, Southeastern Forest Experiment Station, Asheville, N. C.

Profits from Pruning Appalachian White Pine. Robert A. Campbell, Southeastern Forest Experiment Station, Asheville, N. C. Summarizes results of a 19-year test of healing and growth rate of white pines after pruning and analyzes profit of the pruning operation.

Financial Aspects of Pruning Planted Slash Pine. Frank A. Bennett, Southeastern Forest Experiment Station, Asheville, N. C. Presents cost and return figures for pruning planted slash pine.

1955 Annual Report. Southern Forest Experiment Station, New Orleans, La. Reports developments in utilization in sawmill and pulp industries; forest economics; insects; disease research; range management research; watershed management research; forest management, and reviews publications devoted to forestry in the South published in 1955.

Pine Prices Mirror Timber Differences. Southern Forestry Note No. 102. Southern Forest Experiment Station, New Orleans, La., March 1956. Discusses pine price behavior, tests on sweetgum saplings, reforesting spoil banks, longleaf seedfall.

Influence of Timber Characteristics Upon Stumpage Prices. Sam Guttenberg, Southern Forest Experiment Station, New Orleans, La. Occasional Paper 146, 1956. Summarizes results of an analysis of stumpage prices for the period January 1949 through March 1955, consisting of records of 334 southern pine sawtimber sales from National Forests in Mississippi, Louisiana and Texas.

Lumber From Forest To You. National Lumber Manufacturers' Assn. 1319—18th St. N. W., Washington 6, D. C. 32-page booklet tracing the growth of lumber manufacturi : in

(Continued on page 42–A)

PAUL BUNYAN BARBECUE SPONSOR, ASHEVILLE, JUNE 6

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CAMBIO BARKER

Outstanding development of 1955 in wood waste utilization was the introduction of Soderhamn's CAMBIO log barker.

Completely automatic in operation, the revolutionary CAMBIO is the only barker to bark soft or hardwood logs down to 3 feet in length at speeds up to 150 feet per minute.

The unit is self-contained and easily installed wherever electric power is available. Built to American standards, the new CAMBIO BARKER is engineered for fast, efficient barking, plus unusually low installation cost. Available in capacities from 2″ to 42″ log diameter.

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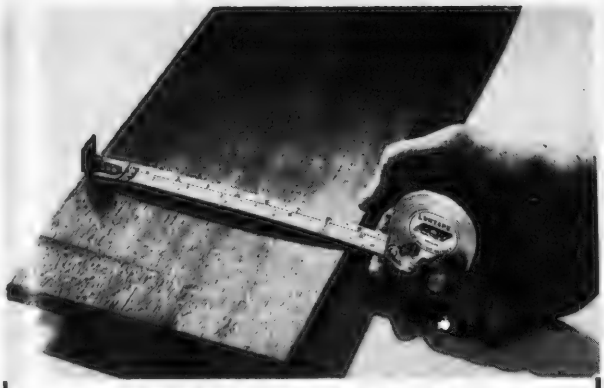

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NEW PUBLICATIONS

(Continued from page 40–A)

the U. S. from establishment of the first sawmills in the early 1600's to its present day status.

The following publications are available without charge from the U. S. Forest Products Laboratory, Madison, Wis.

Some Books and Pamphlets on Finishing of Wood and Furniture. Technical Note No. 195. Revised March, 1956.

Raised, Loosened, Torn, Chipped, and Fuzzy Grain in Lumber. Report No. 2044. Discusses known and probable causes of these defects and suggests remedies and methods of prevention.

Resin Distribution in Second-Growth Ponderosa Pine. B. H. Paul. Report 2046. Presents the results of tests to determine the effect of resin distribution on the specific gravity of ponderosa pine and indicates that the presence of resin might result in faulty interpretations of the effect of environmental conditions on the wood, particularly in forest management studies.

Variations in Fiber Length of Eastern Cottonwood. M. Kaeiser. Report 2047. Presents the results of tests to determine the effect that age and the amount and direction of lean in a tree have on the length of the fibers.

Humidity Controls for Conditioning Rooms. T. C. Scheffer. Report 2048. Describes simple, inexpensive hygrostats and humidifiers that can be used to control relative humidity in rooms used to condition lumber and other wood products.

Determination of Mechanical Properties of Adhesives for Use in the Design of Bonded Joints. E. W. Kuenzi. Report 1851. Describes test methods for determining the basic mechanical properties of adhesives subjected to shear or tension in bonds between relatively rigid adherends.

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VICTORY CARBIDE TIPPED SAWS
ENGINEERED TO CUT . . .
UNIT COSTS
Victory Saws are manufactured to answer today's rigid requirements of top quality wood-working and lower unit production costs.
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Positions Offered

No. E 225—Large progressive Texas firm plans training program to develop production management personnel for South's newest and largest all-electric forest products plant. Seeks recent or June 1956 forest utilization graduates interested in fields of power generation, product shipment, machine finishing and primary production. (May)

No. E 226—Research position requiring Ph.D. or equivalent in wood technology or pulp and paper for Group Leader in Research Center. Strong background in chemistry and understanding of polymeric materials desirable. Reply in confidence enclosing complete resume to the Borden Co., Chemical Division, Philadelphia Research Lab. P. O. Box 9524, Philadelphia 24, Pa. (May)

No. E 229—Eastern veneer and plywood manufacturer seeks recent wood technology graduates, preferably with one or two years experience in some phase of woodworking for sales careers. Will consider current graduates for training program. (May)

No. E 229a—Eastern veneer and plywood manufacturer seeks experienced man for plant superintendent. (June)

No. E 230—Southern state forest service seeks men holding M.F. or Ph.D. degrees with specialization in wood technology or wood utilization for combination investigative research and educational work. (June)

Employment Wanted

No. 323—Immediately available. Man with B.S. Forestry. Experience in yard supervision, pre-cutting (housing), limited marketing, milling, grading, selective logging, cruising, small plant layout and production shortcuts, supervising, and training technical, clerical and labor. Age 54. (May)

No. 328—Graduate in forest products; West Coast; experienced in supervision, administration, sales and research. Young, energetic, excellent references and performance record. Consider any outstanding management level opportunity in production or sales. (June)

No. 354—B.S. Forestry, June 1956. U. of Michigan. Age 21. Several summers with U. S. Forest Service and lumber company, seeks job in forestry. (May)

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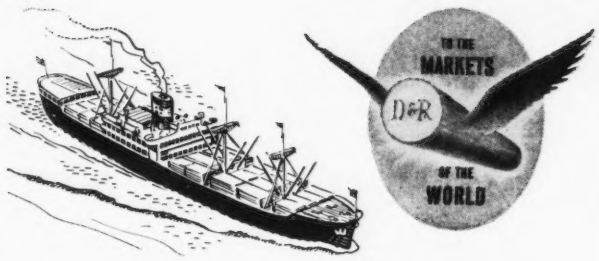

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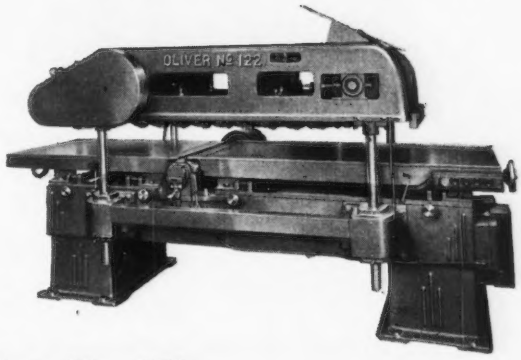

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delivers up to 60 feet a minute
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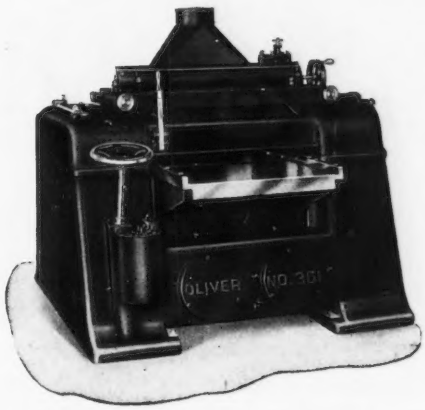

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Oliver No. 361 Surfacer

This Oliver Surfacer smoothly planes all woods up to 30 inches and 36 inches wide, up to 8 inches thick, at speeds up to 60 feet a minute. One-piece wedge type bed. Working parts kept in permanent alignment. Micrometer adjustment aligns bed and cylinder. Easy and convenient to set up and run. Write for Bulletin No. 361.

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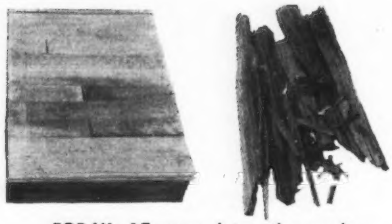

TODAY, 17 years later, the results.

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Monsanto Chemical Co. ---- 2–A
National Casein Co. ---- 9–A
National Starch Products Co. ---- 5–A
Oliver Machinery Co. ---- 43–A
Perkins Glue Co. ---- 28–C
Protection Products Manufacturing Co. ---- 14–A
Radio Receptor Co., Inc. ---- 28–B
W. H. Rambo ---- 39–A
Soderhamn Machine Manufacturing Co. ---- 40–A
Solem Machine Co. ---- 8–A
Robert Speller & Sons ---- 30–A
Spotnails, Inc. ---- 38–A
Standard Dry Kiln Co. ---- 29–A
Synvar Corp. ---- 15–A
Victory Carbide Saw & Tool Co. ---- 42–A
Washington Iron Works ---- 10–A
Williams–White & Co. ---- 16–A

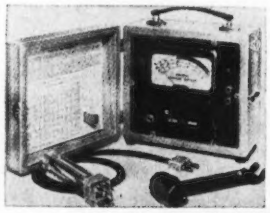
YOU NEED AN M.D.*

. . . to determine whether your lumber is dried to the right moisture content.

. . . if you encounter warpage or end checking during production.

. . . if your customers are complaining of shrinkage or swelling.

. . . to learn whether you are paying freight on excess moisture.



***Delmhorst Moisture Detector**

A Delmhorst Moisture Detector makes it easy for you to know the moisture content of any wood in a matter of seconds without involved calculations. Yet the instrument is so low priced it pays for itself in a short time!

MAIL THE COUPON BELOW TO DELMHORST INSTRUMENT CO. FOR FREE INFORMATION ON USING LUMBER AT THE RIGHT MOISTURE CONTENT. NO OBLIGATION—OF COURSE.

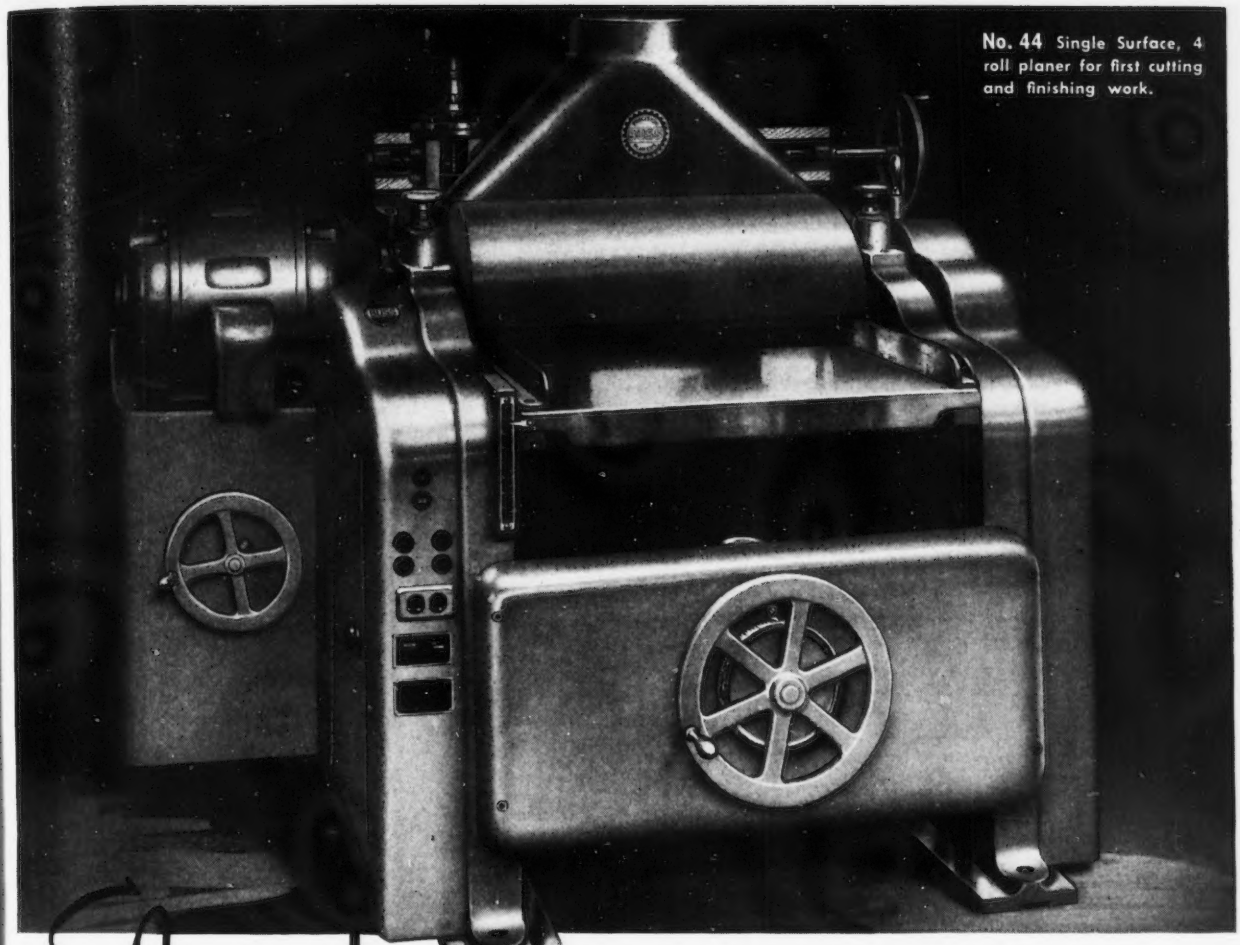
DELMHORST INSTRUMENT CO., 619 CEDAR ST., BOONTON, N. J.

Please send information to:

Mr. _____

Title: _____

(Attach to your letterhead)



No. 44 Single Surface, 4 roll planer for first cutting and finishing work.

Eliminate THE THIEF IN YOUR PRODUCTION LINE

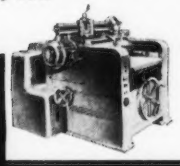
that old planer that seemingly plugs away so faithfully. Sure it keeps on running and does a fair job, but it soaks up many times the man and machine hours that a modern BUSS Cabinet Surfacer would require to do the same work better. And that means it is constantly robbing you of a good share of your profits. Consider for a moment that Modern Buss Surfacers provide finest finish planing at speeds as high as 80 f.p.m. . . . that most adjustments are made semi-automatically and instantaneously, in just a fraction of the time required on the older machines . . . also that the knives on these machines can be kept in perfect condition with relatively little time and effort. These are just a few of the many advantages that Buss Machine Works, through its many years of specializing in the building of planers EXCLUSIVELY, has been able to incorporate in their present surfacers.

Write **for bulletins describing these machines in detail and you will readily understand why we say it is usually far cheaper to own them than to do without them.**

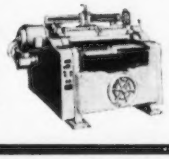
THERE'S A BUSS PLANER TO EXACTLY SUIT YOUR NEEDS

6 MODELS
29 SIZES

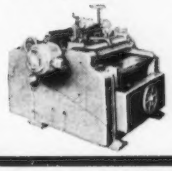
No. 4-L Single Surface, medium sized planer for first cutting and finishing work.



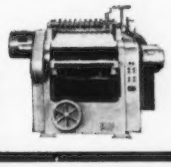
No. 66 Single Surface, 6 roll planer for first cutting and finishing work.



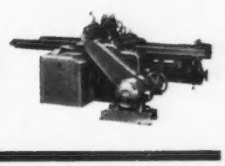
No. 88 Double Surface, 8 roll planer for first cutting and finishing work.



No. 55 Heavy duty Double Surfacer for planing rough lumber.



MICRO-SURFACER for planing hardboard and other very thin materials.



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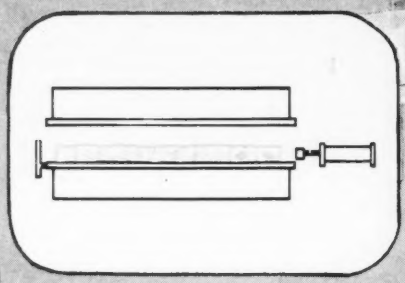

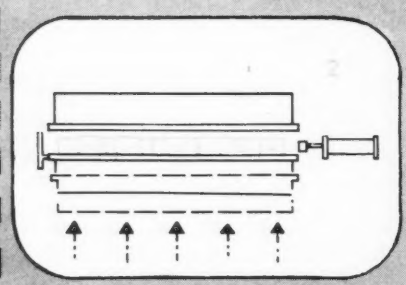

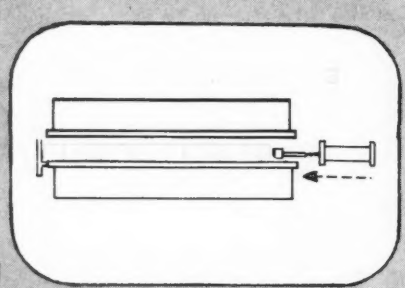

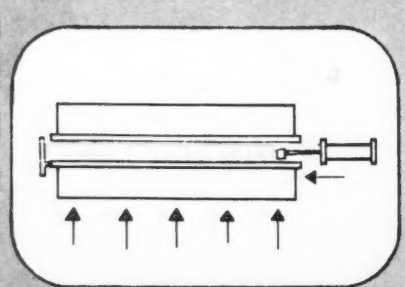

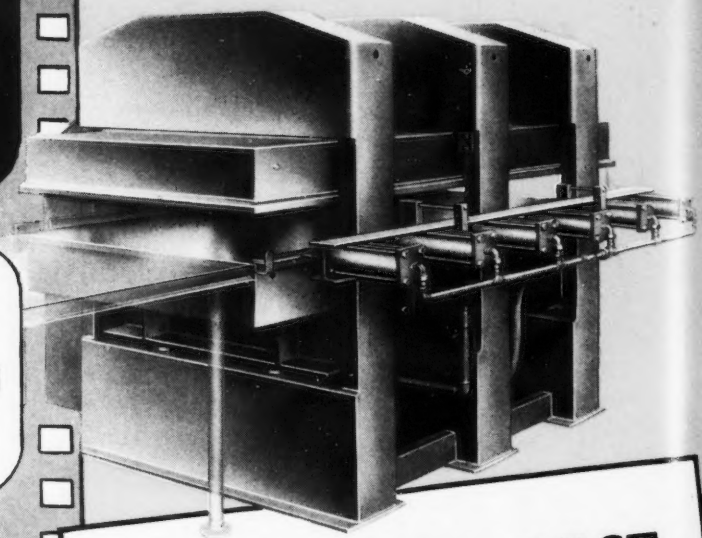

NOW...LOW COST EDGE GLUING OF CORE STOCK—

Utilizing exclusive Berthelsen side pressure attachments on either a single or double opening Berthelsen Press provides manufacturers with a low cost batch-type edge gluing machine.

Diagrams at left illustrate operation of the press as follows:

1. **Press loaded with random or gang ripped core stock with good glue line edges.**
2. **Curing cycle starts. Platens quickly close to a pre-set position to prevent stock from buckling (face pressure is not yet applied).**
3. **Side pressure attachments, apply controlled horizontal side pressure at the precise moment the pre-set position is reached.**
4. **Press completely closed. Application of controlled heat, vertical and horizontal pressure fully coordinated to effect glue cure.**

Production averages up to 5000 sq. ft. per 8 hr. shift per opening. Operating cost is low, maintenance of the equipment is simple. Moderately priced, this Berthelsen Press is within reach of the smallest manufacturer. Write today for full details.

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